The MINING CONGRESS JOURNAL

Volume 13 SEPTEMBER, 1927 *No.* 9

ANNUAL METALS EDITION

Mechanization at United Verde Mine
Electric Shovel Operation at Utah Copper Mine
Hoisting Operations at Desloge Consolidated Lead Company
Improvement In Converter Practice
Page Mill of Federal Mining & Smelting Company
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Metal Mine Tax Laws of Western States
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Public Land Ownership
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Entry Driving With Mechanical Loaders at C. & O. Mines
Necessity for Short Flame Explosives in Coal
Reports of the Mechanization Survey

Contributors:

A. G. Mackenzie, C. E. Mills, C. W. Corfield, R. J. Corfield, R. W. Diamond, W. L. Zeigler, Guy H. Ruggles, Henry F. Adams, E. H. Mohr, A. T. Tye, A. W. Fahrenwald, E. W. Parker, W. B. Gohring, G. B. Southward, H. A. Neustaedter, Herbert B. Husband, D. Harrington, G. St. J. Perrott, Leonard Larson, H. G. Washburn.

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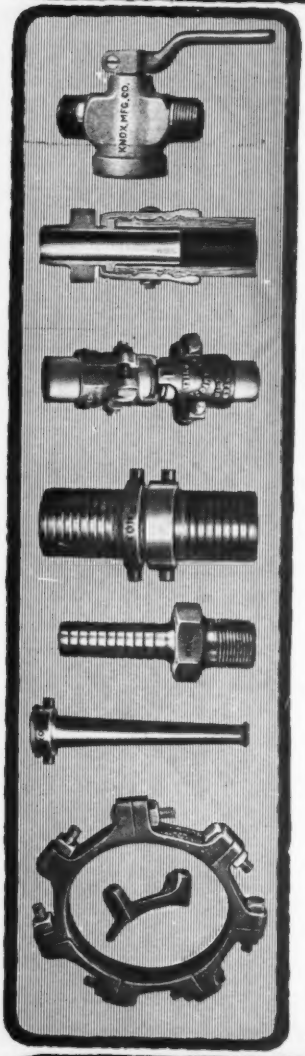

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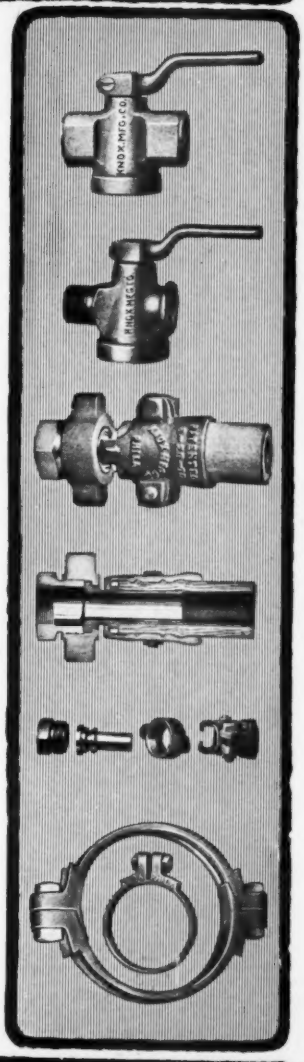

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PRACTICAL OPERATING MEN'S DEPARTMENT

COAL

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METALS

Hoisting Operations and Equipment at No. 7 Shaft, Desloge Consolidated Lead Company
General Improvement in Converter Practice
The Federal Mining & Smelting Company's Page Mill

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E. R. COOMBES, *Editor*
McKINLEY W. KRIEGH, *Assistant Editor*
GUY N. BJORGE, *Associate Editor*

NEWELL G. ALFORD, *Associate Editor*
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F. E. PRIOR, *Art Editor*
J. R. HURLBURT, *Field Representative*

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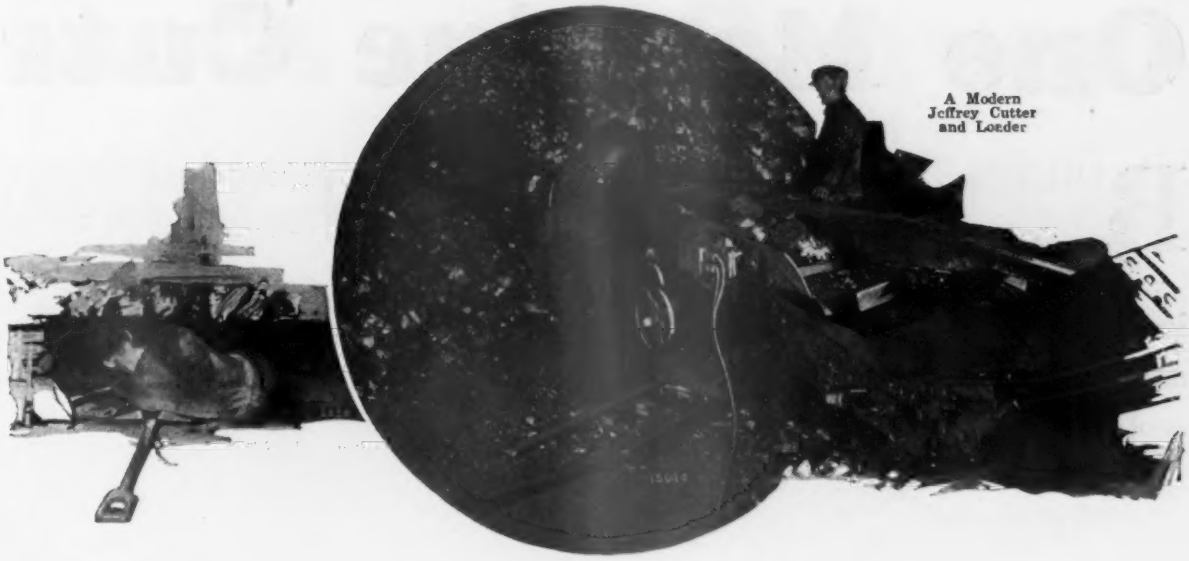

A Modern Jeffrey Cutter and Loader

50 Years Ago

Back-breaking, slow, dangerous, costly—words such as these describe the task of mining coal a half century ago, but not today.

In 1877, Jeffrey introduced the first practical machine for cutting coal. Other needs were recognized and Jeffrey machines were designed to meet them until today human drudgery in coal mining is practically a thing of the past. Machinery now performs the work with greater speed, greater safety, and greater economy.

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Jeffrey Engineers are continually anticipating the needs of the mining industry and designing machinery to meet those needs. One of their most recent developments is shown on the next page.

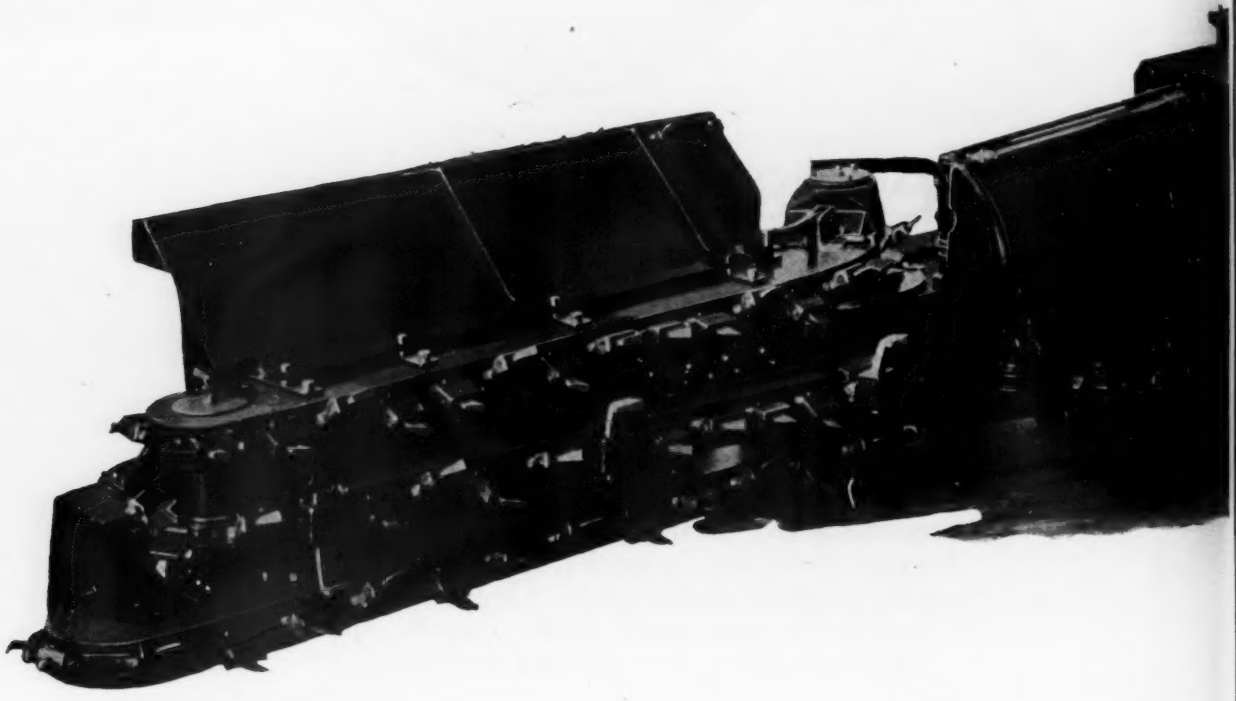
—and Today

One Machine Cuts,

BUILT like the cutter bar on a Jeffrey Shortwall Coal Cutter, the cutter bar on the Shortwaloader will under cut on rolling bottom and will cut around impurities and hard spots in the seam.

as the Shortwaloader moves across the face pulling all the coal onto the conveyor.

The special loading bits will even pull down the standing coal that still clings to the face after the shot.



Above the cutting bar are the two loading bars that drag the shot coal onto the conveyor part of the machine. The loading bars swing out of the way while the cutter bar is at work. After shooting all three bars are fed through the coal

The conveyor on the rear of the Shortwaloader has a swinging boom which allows it to load the coal onto a stationary mine conveyor while moving across the face.

No time is lost in taking the machine in and out of rooms—it operates contin-

50 YEARS OF SERV

Loads and Conveys

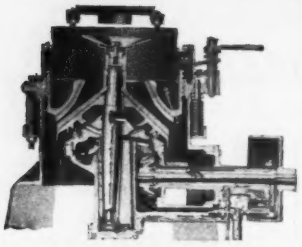
Jeffrey 43-A Shortwaloader

uously in one room or entry until the place is worked out.

This means a large saving in time, labor and equipment. The working area is concentrated and production costs per ton are much lowered because of the smaller amount of equipment needed for tracks, timbers, ventilation and safety inspection. Furthermore, the safety inspectors have less territory to cover and the men working at the face come under more direct supervision.

Some performance records of this triple-duty machine will be found on the next page.

SYMONS



Sectional — showing Positive Oiling System

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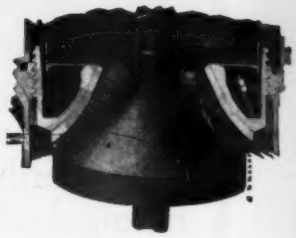
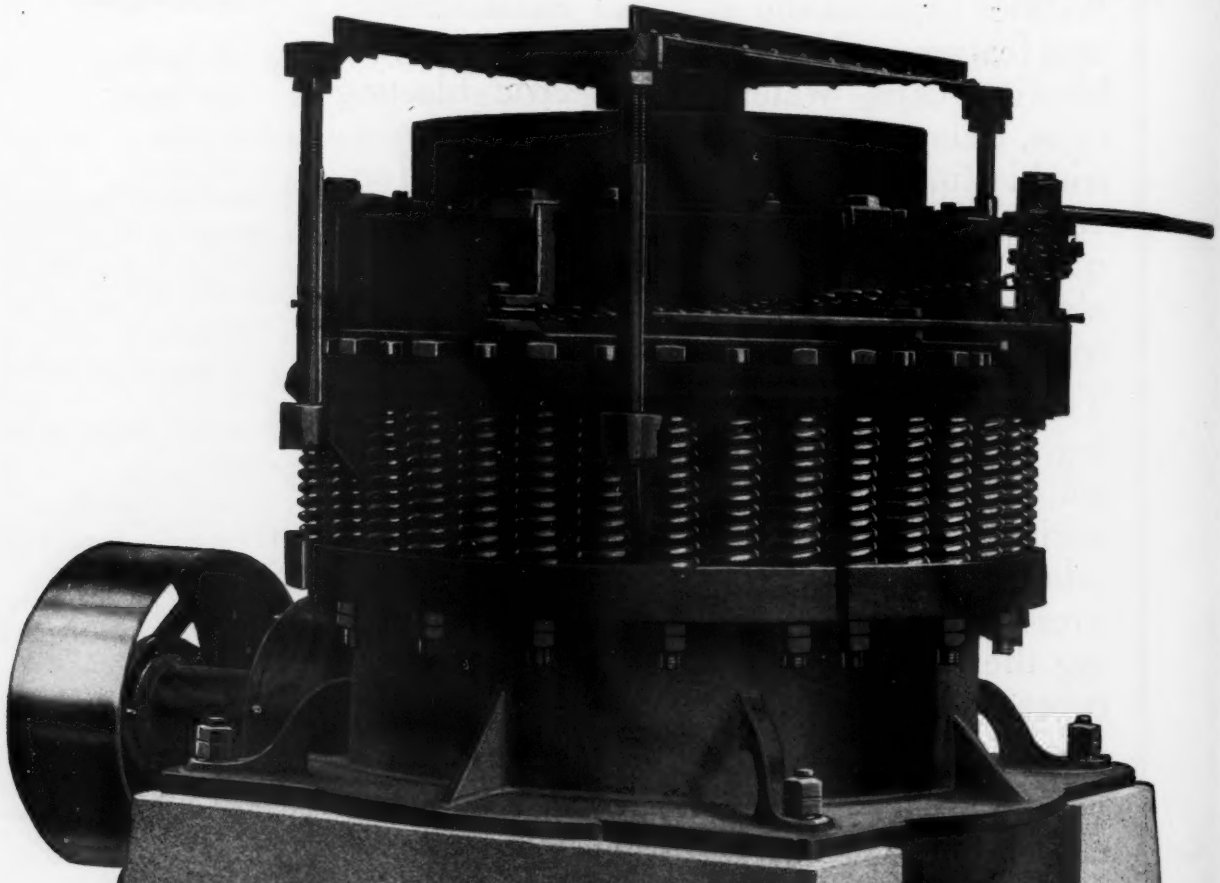


Illustrating the crushing action of the Cone



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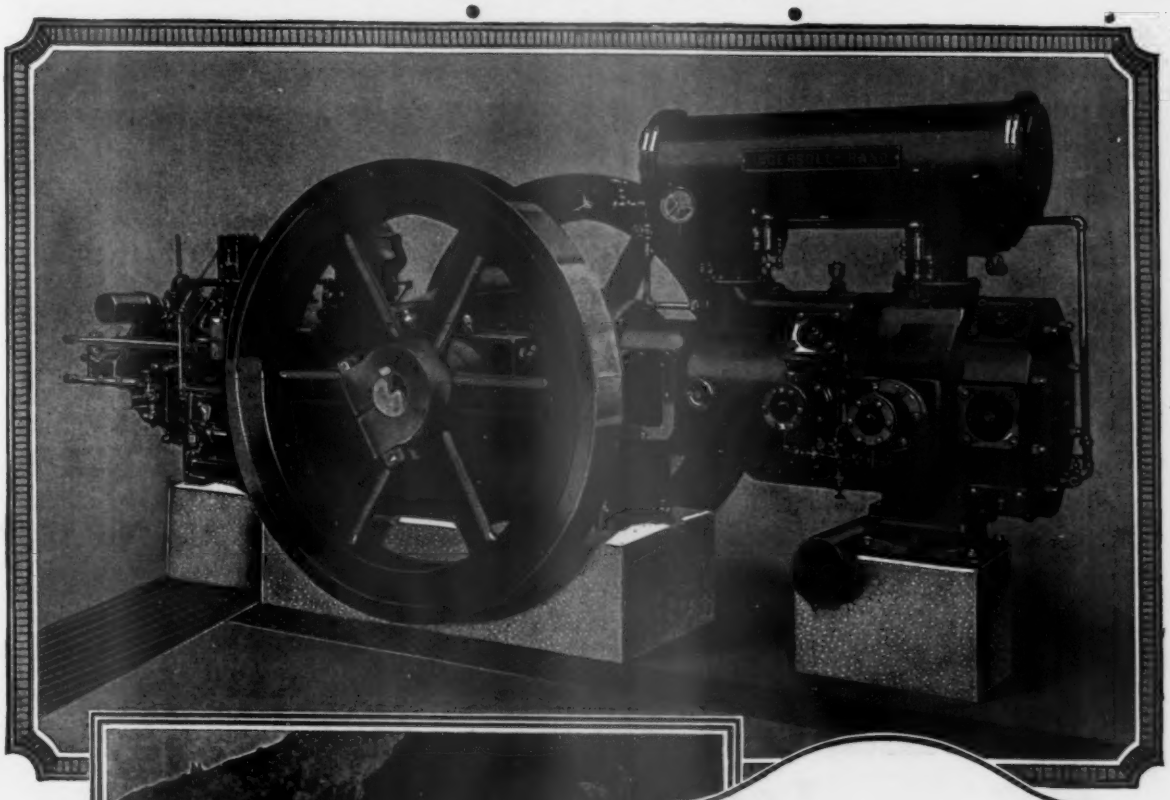

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The Ingersoll-Rand Oil Engine Air Compressor and I-R Rock Drills are an unbeatable team in the game of cost reduction. In quarries, mines, and contract work, I-R Rock Drills are constantly demonstrating their superiority. Type POC Air Compressors have proved their reliability and low-cost operation in numerous installations.

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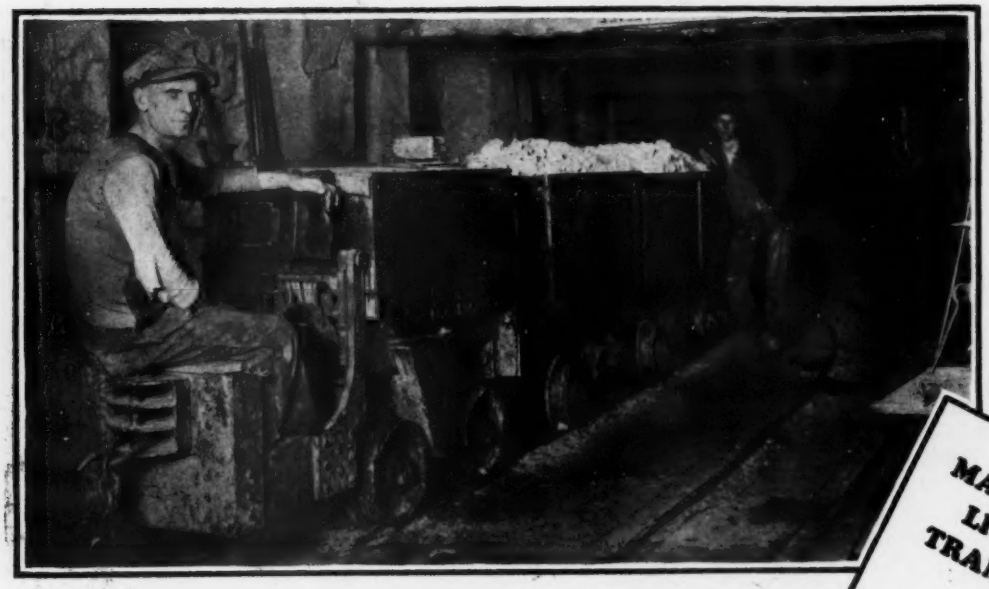

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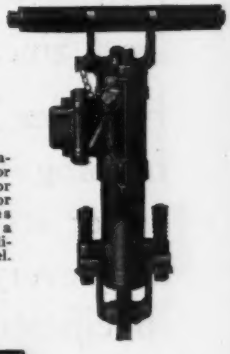

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New "L-7" Auger Rotator

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New L-5 Rotator

A new 75-lb. hand-held Rotator, for shaft sinking or any heavy down hole work.

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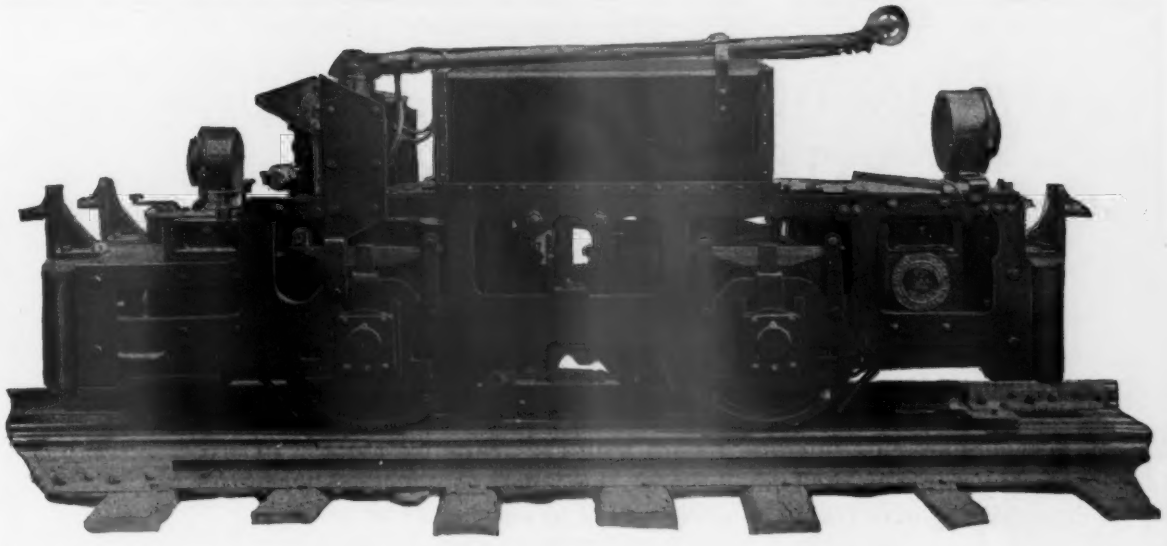

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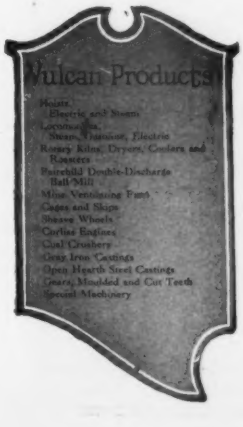

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Washington Beautiful—A Driveway in Rock Creek Park © *Horydczak*

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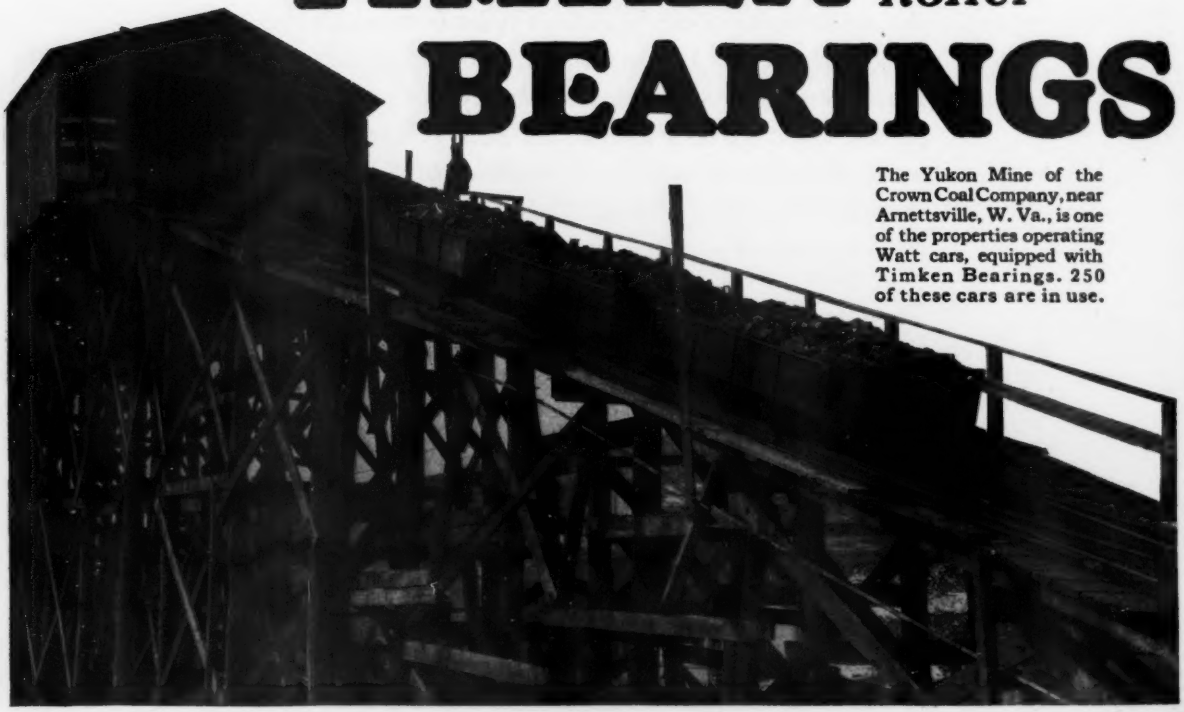
TIMKEN *Tapered Roller* **BEARINGS**



The Yukon Mine of the Crown Coal Company, near Arnettsville, W. Va., is one of the properties operating Watt cars, equipped with Timken Bearings. 250 of these cars are in use.

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STABILITY OF THE MINING INDUSTRY

THE MINING INDUSTRY, generally speaking, has laid its foundation well. It has planned well with respect to the future by keeping development of reserves far ahead of production. Its engineers engaged in research have developed methods of mining, treatment and beneficiation that have created vast reserves of ore that once were waste rock. The manufacturers of its machinery and equipment have developed numerous devices and improvements that have kept costs of production down and made it possible for production to keep pace with consumption. Its chemists and research engineers have discovered and developed new uses for the various minerals. And all of this work is going forward continuously, is meeting the needs of the industry, and is enabling it to supply the increasing requirements of civilization.

Tariff protection has helped immeasurably in building up the domestic metal-mining industries, and has served to bring this country nearer the desired goal of complete economic independence from the rest of the world. The continuation of a wise tariff policy will insure the maintenance of good wages and the superior standards of living that prevail in the mining districts of this country.

The mining industry is stable. While the risks and hazards of new mining ventures are greater perhaps than in many other new enterprises, the opportunities for rewards commensurate with these risks and hazards are as potent as at any time in the history of the mining industry. But when a new venture has been brought to the production stage, and has reached a dividend paying basis, the risks and hazards largely disappear, and stocks in such enterprises take their place in the investment markets along with railroad, manufacturing, and other industrial stocks.

Mine management and accounting has been developed and perfected to a high state of efficiency. Safety problems have been analyzed and met with ingenious skill. Standards in mining methods and equipment have been worked out with a high degree of success. And waste and inefficiency have been largely eliminated.

The public too often ignores the importance of the mining industry as a factor in national prosperity, notwithstanding that it pays the major portion of the taxes collected in a score or more of states, furnishes direct employment to more than a million citizens, and indirectly to several times that number, provides more than 50 percent of the annual freight tonnage of the railroads, and supplies the raw materials for the manufacture of most of the conveniences and luxuries of life.

Mining is a basic industry. The miner is one of the primary developers of natural wealth. The industry merits every possible encouragement. And the public as well as the state and Federal governments should guard and protect it against every move that might jeopardize the stability it has created largely as the result of the efforts of those who have devoted their lives and fortunes to its development, improvement and expansion.

THE WESTERN DIVISION MEETING

EXPERIENCE HAS PROVED the wisdom of the getting-together habit, the mutual discussion of problems, the exchange of ideas. The fifth annual meeting of the Western Division of The American Mining Congress, just closed at Salt Lake City, justified the above conclusion. As in previous years, the American Institute of Mining and Metallurgical Engineers and the American Silver Producers Association held meetings simultaneously, discussing problems of special interest to those organizations. The Western Division program was confined exclusively to discussion of economic problems of the metal industry, special emphasis being given to mine taxation.

While the growing importance of mining to the national welfare is well understood, especially interesting figures were given by Mr. L. S. Cates, vice president of the Utah Copper Company, showing that while the United States is the greatest producer of mineral products in the world, it is likewise the greatest consumer. He pointed out that metal consumption per person in the United States in 1926 was 15 pounds of copper, 13 pounds of lead, and 10 pounds of zinc, whereas the figures for Great Britain, France, and Germany are much lower, United States per capita consumption of copper being more than double that of the other leading nations, with relative proportions as to lead and zinc.

The significance of these figures to the industry indicates the magnitude of the task presented to the mining men in attendance at the convention. The further development of home markets, the exportation of our surplus production, the necessity for maintenance of the protective tariff, an equitable basis of taxation, both state and national, are a few of the complex and intensified problems which were discussed, and upon which recommendations were made for transmission to The American Mining Congress.

These meetings do much to bring about better understanding between the different sections of the industry, a closer spirit of fellowship, a keener appreciation of industry as a whole, and the difficulties peculiar to each of its branches. Each is thus enabled to guard against injury to another in any effort made in its own behalf to secure relief from its own problems. These meetings are well worth while, and the one just closed was an excellent example of what may be accomplished by the getting-together habit.

THE COLORADO RIVER COMPACT

THE DEVELOPMENT OF POWER and the reclamation of desert lands is responsible for the marvelous strides that have been made in the western states toward economic independence. From the Canadian border to the Gulf of California and the Rio Grande, great power and irrigation projects have been completed and are functioning successfully, with the result that the western states have increased their populations, developed industries dependent upon power, and built up agricultural districts that are second to none in the United States. The further use of the waters of the rivers of the Rocky Mountain and Pacific Coast states for power and reclamation is possible and essential to aid in increasing the population by migration and to meet the needs of the present populations and growing industries of these states.

It is recognized that the Colorado River is the greatest single undeveloped resource in the West, if not in the United States. Nearly six years ago the first notable conference on the development of the resources of the Colorado River, following the creation of the Interstate Colorado River Commission, was held at Riverside, Calif. At that time official representatives and citizens of the seven states drained by the river and its tributaries were enthusiastically in favor of immediate action on the part of their respective states and the Federal Government looking toward the harnessing of the potential resources of the Colorado and the reclamation of large areas of virtually desert lands that could be irrigated. The mining interests of these states also were behind the general program, as the development of cheap power meant greater development and production in mining the vast reserves of low grade ores that exist in the Southwest. The situation seemed so favorable and the project so feasible that no one would have predicted then that controversies would arise of sufficient magnitude to delay indefinitely the commencement of actual work on the project.

It was not until the State of Arizona refused to ratify the famous Colorado River compact which was signed by the representatives of the seven states, including Arizona's representative, that those interested in and in favor of immediate development realized that there were questions involved pertaining to the rights of the several states that would have to be determined before any work could be authorized and started. Thus far these questions have not been settled. The State of Arizona still refuses to ratify the compact, undoubtedly for just and sufficient reasons, and in the meantime some of the other states, parties to the agreement, have raised questions that must be settled before anything can be done. The State of Utah petitioned the President and Congress asking that no action be taken until the states have settled their differences.

Aside from the general question of allocation and use of the waters, as between the states interested, there are questions of taxation; whether the power plants shall be constructed and operated by the Government, leased, or privately owned and operated; jurisdiction over non-navigable streams; and many others of more or less importance. With respect to taxation, it is questioned whether Arizona or the other river states can derive any substantial benefits, whereas, it is contended, the project will result in great enhancement of taxable resources in California.

It may be that a compromise settlement will result from conferences of representatives of the seven states interested. At least they may be able to agree upon a program that will expedite the matter and perhaps result in Congress proceeding with plans for proper utilization of the Colorado River for power development, reclamation and other uses. One such conference has just been held. However, even if these states reach a satisfactory settlement of the controversy over water rights, the political and economic features of the matter are of such importance that early action by Congress is not anticipated. While the development and utilization of the vast potential resources of the Colorado River and the reclaiming of large areas of desert lands through irrigation are of great importance, both locally and nationally, neither the states nor Congress should act so hastily that the way will be left open for the inauguration of any scheme of Government ownership, operation and control of industry. Humanitarian as well as economic reasons require early action if this generation is to receive any benefit from this great resource. But no right of sovereignty or principle of constitutional government should be sacrificed for any socialistic theory of governmental functions in order to get authorization for the project through. The ultimate treatment of this important problem will demonstrate the sagacity of our present-day statesmen.

THE FUTURE OF GOLD MINING

THE GOLD MINING INDUSTRY of the United States has been stifled under the tremendous handicap of high costs of production which have prevailed during the last ten years. With the price of gold fixed by a Government century-old standard, with the market for gold for uses other than coinage satisfied by the Government's supply, and with high-grade ores practically exhausted, most of the gold mines have had to close down.

It is the duty of the Government to foster the industry under these circumstances, and there are several ways by which the gold mining industry can be given relief. The Government can raise the price of gold for uses in the arts; it can exempt gold mining from the income tax without incurring any material loss of revenue, because such an exemption would aid the industry in securing needed capital, and the stimulation of the industry would be helpful from a taxation standpoint; the State of California can permit the resumption of hydraulic mining; and prospecting can be stimulated by removing restrictions that now exist upon prospecting on the public domain, particularly on public lands classified under the stock-grazing homestead act, or reserved under the national forests and leased for grazing purposes.

Many gold mines await financing. But the usual sources of funds have been closed due to the adverse conditions, both economic and political, which can not be overcome except through legislative action. The continual interference of state blue-sky laws, and the possibility of Federal blue-sky legislation which would unnecessarily subject gold-mining enterprises to long-range analysis and perhaps a sort of political domination, also help to prolong the depression of this industry.

Unless necessary measures of relief are evolved and applied, the future outlook for gold mining is not hopeful. Present-day statesmen seem to have forgotten the importance of the industry in the development and reclamation of the West. It is high time that the problems of the gold miners be considered and steps taken to remove the handicaps that are threatening the industry with early extinction. Large resources in the form of low-grade ores exist, and these should not be abandoned.

Justice and economic necessity favor prompt relief for the gold miners. Congressional investigations have produced ample evidence of the conditions that exist, and all that is needed now is far-sighted statesmanship, and sympathetic recognition of the gold miners' problems, on the part of Congress, in enacting desired legislation. The Government is largely responsible for the present situation in the industry, and it should do everything in its power to improve that situation. The whole country would rejoice to see gold mining again flourish and thrive as in the past.

WILL CORPORATE TAXES DIMINISH?

THE QUESTION of whether the taxation burdens of corporations will become less or more during the next ten years depends largely upon the trend of state and local taxation. That trend is sharply tilted toward the sky at present. Will it level off for awhile and then gradually drift downward? There is every indication that the next Congress will make some reduction in the corporation income tax rate, perhaps to 10 percent. But if, like every other reduction in taxes made by the Federal Government since the war, the states and their political subdivisions immediately take up the slack by increasing their taxes, this reduction will afford no relief to business.

Corporations are an easy prey for the tax gatherers. Whatever may be their superior advantages over individual enterprise in respect to production, trade and commerce, they are marked insofar as taxes are concerned. In the past public opinion has been swayed against them through propaganda and distortion of facts by those who seek to swell the public revenues for the maintenance of the numerous tax-spending agencies of which many are the creation of self-promoting politicians and not the outgrowth of public necessity. Thus, when the people are asked to vote upon a proposition where the interests of the politicians clash with the interests of corporate business, the loud cries of the former drown out the plaints of the latter, and the politicians usually win.

It is very difficult, as a rule, for the average citizen, unschooled in the arts and wiles of political maneuvering, to get at the fundamentals of any question that stirs the political atmosphere, especially where corporations are involved. To the average citizen, the corporation has been an inanimate thing without soul or feeling. Fortunately, during the last decade, some 20,000,000 voters have become stockholders in corporate enterprises, and as these enterprises add to the number of their stockholders, their problems are more generally understood, and it becomes increasingly difficult to deceive and hoodwink the public.

So that in levying taxes, state and local governments as well as the Federal Government are finding that a great body of the citizenry stands united on the question of how the levies should be made and the manner of their distribution or spread over the taxable resources of the country. If the next Congress makes a reduction in the corporation income tax rate, it will be in response to popular demand. Likewise, if the state and local governments adopt policies of economy and efficiency in the expenditure of public funds, and succeed in paring down their budgets, it will be the result of public interest in and understanding of their local conditions and necessities, and a general uprising against the present trend of public indebtedness and expenditures.

If corporate enterprises are relieved of harrassment in the form of increased taxes, and the continual attacks upon their capital and earnings cease, the people generally will derive substantial benefit in the form of reductions in the cost of living. If the public so wills, both taxes and the cost of living will come down.

WORKMEN'S COMPENSATION

THE ORGANIZED MOVEMENT throughout the country to raise workmen's compensation benefits without regard to conditions in the several states, and to extend the compensation laws vaguely into the field of health insurance, has raised an issue that is of serious concern to the mining industry. No industry should be held liable to employes to compensate for results for which it is not rightly responsible, yet those seeking to enlarge the application of the compensation laws would have them require the payment of compensation for the actual disability without regard to any preexisting physical impairment or preexisting disease, although the latter may be primarily and perhaps wholly responsible for condition of the claimant. The disease hazard in mining is almost negligible, and the accident hazard is not as great, especially in the operation of developed mines, as in many other lines of occupation.

The enlargement of the compensation laws to include disabilities of whatever cause or nature in the compensable classes, would not only penalize industry unjustly, but would tend to make useless citizens out of workmen whose continuance in industrial employment is essential to the welfare of society as well as to their own health and general well being. Even under many of the compensation laws as they now stand, claims of disability may be allowed which bear no possible relation to the claimants' employment. We believe that in many instances such claims are allowed because of lack of full information, or misinformation, or incompetency on the part of the compensation authorities or their advisers. We are opposed to enlarging the opportunities for such allowances.

The adoption of a uniform compensation law also is a part of the program of the organized movement. Would such a law be practicable or desirable? It must be remembered that conditions vary widely in the different states, especially as between the eastern states where there are densely populated areas, and the western states that are sparsely settled where the population is scattered over wide areas. The problem of administration alone would raise serious doubts as to the practicability of a uniform law for application in any of the western mining states. We believe each state should frame its own laws to meet the conditions of its people and industries with respect to matters of employment, and we do not believe a uniform compensation law for the adoption of the states or a Federal law dealing with this question should be considered.

Another phase of the movement for enlargement of the workmen's compensation laws, is that of state insurance, and a compulsory insurance law to cover automobile accidents. State insurance is a socialistic idea. Radical propagandists who are furthering this movement know that control of insurance is a long step toward Government control of industry. Henry S. Ives, of Chicago, in an address before the Southern Industrial Conference of the American Mining Congress, at Birmingham last March, said: "The danger incident to state operation or control of insurance ought to be ob-

vious because of the vital part it plays in the maintenance and encouragement of free institutions. * * * The greatest single danger from state insurance is the fact that if the state takes over the business, the immense reserves and surplus funds maintained for the protection of policyholders will become an easy prey for spoilsmen. These funds would be available for political speculation, for the purpose of gaining control of property which it might be desired to socialize and for the subsidizing of classes, blocs and parties. * * * There can be no forward movement without the protection afforded by sound insurance, and such protection is not offered freely where the institution itself is subject to extinction or repression by public authority."

State intrusions into the field of insurance and of other lines of private enterprise do not serve to promote industry, prosperity, and general welfare. In some instances they have been hopeless failures. Experience with these experiments warrants the conclusion that government, neither state nor Federal, should engage in a type of business which private concerns have adequately demonstrated their ability to conduct efficiently and expeditiously.

The payment of reasonable compensation to disabled workmen who are worthy, and whose disabilities have resulted from their employment, is proper. Their protection is essential to the welfare of society. It is a mistake to place the control of this essential service, made available and now being efficiently rendered by private companies, for employers and employes in industry, in the hands of a governmental agency that is necessarily affected by political controversies and bickerings. Neither the mining industry nor any other industry desires further governmental experiments in this field. And the workmen themselves, if they will investigate and reach a full understanding of the question, will find that such experiments have not served and will not serve their best interests.

AMERICAN BAUXITE

A RECENT RELEASE by the Department of Commerce on the manufacture of aluminum from clay, says that the United States is one of the largest producers, both actually and potentially, of aluminum and pure aluminum compounds. It continues, however, that the Nation is increasingly dependent on bauxite imported from abroad for raw material used in these industries.

Account is then given of investigations in acid extraction processes both at home and abroad, and the conclusion advanced that for political as well as economic reasons, it would be well to develop processes looking toward the utilization of other aluminous materials within our own borders, as Norway, Germany and Italy have done.

Of consuming interest however, is the statement that since the World War it has been realized that our supply of bauxite is far from inexhaustible, and that distribution from existing deposits can be easily shut off in time of war, or placed under irksome government and economic control in time of peace.

The natural inference from this is that American bauxite deposits are meager, and only to be used in an emergency. Yet if we turn to the latest volume of "Mineral Resources of the United States" we find the States of Alabama, Arkansas, California, Georgia, Mississippi, Missouri, Tennessee and Utah all listed as commercial sources of bauxite, while it is well known that North Carolina, Texas and Virginia also carry high grade bauxite deposits.

The south Georgia bauxites are well defined, and have been opened in numerous places. The Mississippi bauxites are so high in grade and so plentiful that a special state bulletin on Mississippi bauxite has been issued by both the state and United States Geological Surveys.

When we search therefore, for the Ethiopian in the wood pile, we learn that exactly as in the case of several other minerals which enjoy strong competition from abroad, the question of the tariff weighs heavy in the balance. But with this distinction: that no dispute arises as to the quantity or quality of American bauxite reserves.

The great consumers of bauxite very naturally buy foreign ore, when by so dong they can ship and deliver it to the point of fabrication for a less price than it would cost to pay a normal American working-wage for the development of American industry. Were a sufficient tariff placed on materials in this category, to equalize the pauper wage abroad with a working wage here, we should see spring up in a half dozen states, an active development of bauxite, which would immediately be reflected in increased markets for farm produce, expenditure of local payrolls in a score of towns, and a wave of prosperity spread itself over the area in question.

The plea that cheap bauxite would mean cheap aluminum ware and chemical alum, is a bogy long ago dissipated into political limbo. A tariff equalization such as has been described, would increase the actual cost but a few cents per unit, while the wages paid to American labor employed would be reflected in food, clothing, automobiles, and general expenditures, with corresponding increase in bank deposits, railroad travel, and every form of enjoyment which comes with a high standard of living.

Aluminum is principally a product of labor, whose manufactured value is about 2,000 percent of its raw material value. The bauxite must be mined, treated, transported and put through chemical process; the coal must be mined, transported and its energy turned into steam, or hydro-electric plants must be built and operated; the limestone must be quarried, transported and treated; salt must be mined and transformed by chemical process into soda ash; cryolite must be mined in the Arctic and brought to the scene of reduction; by-product carbons of the coal tar and oil industries, and fluorspar, must similarly be produced and transported. It is estimated that five tons of bauxite require 27 tons of other materials to produce one ton of aluminum. Aluminum, therefore, more than any other metal, is a labor assemblage and a labor product.

From which it is obvious that an adequate tariff on bauxite could have but one effect, and that would be an astounding development of our own domestic bauxite deposits, employment for large number of American workmen, improvement in surrounding agricultural areas, and an industry independent for all time, of any foreign source for its basic material.

A protective tariff, scientifically scaled, on not only our raw materials, farm products and similar substances, but on cement, brick, glassware and other manufactured products whose foreign labor of fabrication means ruinous competition with American workmen and American standards of living, would make permanent the prosperity which has blessed us beyond any comparison.

A PROGRAM FOR COAL

THE COAL-MINING INDUSTRY can solve its own problems if left alone. That is the contention of the coal operators generally and their leaders, and means simply that they have confidence in their ability to work out their own salvation, if Congress will open the way and remove the threat of government interference. Probably they are right; but they are confronted with an involved situation, which includes much internal disagreement and much outside misunderstanding.

There is internal disagreement over vital questions of production, marketing, and distribution. There is outside misunderstanding on the part of the public due to the flood of unfavorable and misleading propaganda that has been circulated throughout the country over a period of many years and assimilated, particularly by the coal-consuming public. So that if the industry is to succeed in solving its own problems, it must first establish unity within itself, and then must win the support of the consuming public.

That the coal industry is in a bad way is not denied by anyone. The controversy, discord, and confusion is principally over the causes for the existing situation. The miners' union says it is largely due to unfairness on the part of the operators with respect to wages and conditions of employment; some operators, at least, blame it to cut-throat competition; some analysts of the situation say that the industry is overmanned and overdeveloped; a portion of the public at large, under the influence of propaganda, believe it is due to greed on the part of the operators and suspect that a plan exists, concurred in by both operators and union leaders, to bring about a general coal shortage in order to exact high prices; while perhaps the larger portion of the public has given the matter little thought.

The conflict between the operators and the labor union can be dismissed with a word. The United Mine Workers' leaders will authorize the men to go back to work the moment they learn that public sympathy and support, with the aid of which they have hoped to force the operators into submission, is no longer with them. They and the operators will get together and find a satisfactory working basis if and when the labor leaders come to a full realization that the public can no longer be misled concerning the merits of their cause and the reasonableness of their demands. Up to the present time, the labor leaders have been unwilling to meet the operators even half way. The miners, however, may take the matter into their own hands and go back to the jobs and wages that await them, as they are realizing already that they have lost far more than they can possibly gain by holding out longer in the hope of a renewal of the Jacksonville scale or its equivalent.

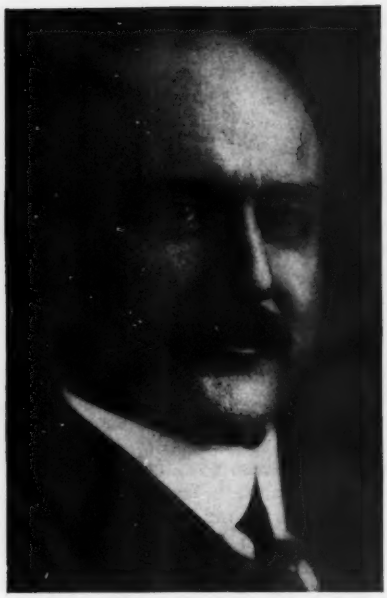
Thus, the question narrows down to what will happen when Congress meets. Just at present it does not appear that Congress will do anything. Nevertheless, it can be assumed that whatever is going to happen in Congress, if anything, will happen whether the operators and the union have adjusted their differences or not. Relaxation of the Sherman law might help materially in the solution of the coal problem, and this is a phase of the matter that Congress ought to consider. Whether or not this is brought up in Congress undoubtedly depends largely upon the attitude of the consuming public. If this conclusion is sound, there is a great deal to be done between now and the time Congress convenes in December; because the consuming public is strong numerically and powerful politically. The public generally does not believe in government ownership. The public is skeptical about government regulation or control. The public generally does not believe in government interference with private business affairs unless the public welfare is at stake. Therefore, the public must be convinced that principles involving the public welfare are not at stake, but on the contrary will be served by a relaxation of the Sherman law. And the first and most important part of the public to be so convinced is the coal-consuming public.

The public has been informed, as the result of the various investigations of the coal industry, that the coal producers are not responsible for the pyramiding reflected at times in retail prices of coal, about which there has been so much complaint in certain sections of the country. The public knows that the producers do not profit, generally speaking, as the result of the alleged pyramiding. But there still exists some doubt in the public mind as to the responsibility of the coal operators for conditions that make so-called pyramiding or excessive retail prices possible. That doubt should be dispelled and the operators should see that it is done for their own protection.

Another powerful factor affecting future congressional policy and action is the attitude of agriculture. The present problems of the coal industry are not dissimilar to those of agriculture. The farmers are said to be in sore financial straits. Likewise, the coal operators. The farmers complain of high tax burdens. What of the coal operators whose taxes, where profits are made, exceed their dividends; and where the net losses of half the industry equal the net profits of the other half? The farmers are said to be suffering from overproduction. The same is true of the coal industry. Costs of production are high in the case of both industries. About the only differences between the two industries are: the coal industry is over-manned while agriculture is not; but agriculture is permitted to make up for any shortage of man power and to lower costs of production by the use of machinery, while the coal industry has been held back from general experimentation, installation and use of machinery by the mine workers and by financial circumstances. Also, the farmers have been given the benefit of a cooperative marketing act and relief from the Sherman law.

There is no apparent reason why the farmers should not support the coal industry with their political strength, since the prosperity of the coal-mining industry, and the manufacturing industries dependent upon it, contributes largely to the prosperity of agriculture. So it would appear that the coal industry can do a great deal for itself by placing the facts about its problems squarely up to the consuming public and the farmers. Neither countenance for a moment the dictation or domination of labor in their own affairs, and probably have little sympathy with such a condition in the coal industry. The farmers, particularly in the West, have been especially vigorous in promptly dealing with the I. W. W.'s and reds who from time to time have invaded the wheat and corn districts. Thus, both the coal industry and agriculture are on a common ground.

Most of the untruth and misinformation spread about the coal industry has been dispelled by the dissemination of the actual facts resulting from the coal investigations of recent years. The way has been opened for coal to proceed with the education of the public. In the gaining of full public confidence and good will lies future security and prosperity for the coal industry, and time within which to work out the solution of both its internal and external problems.



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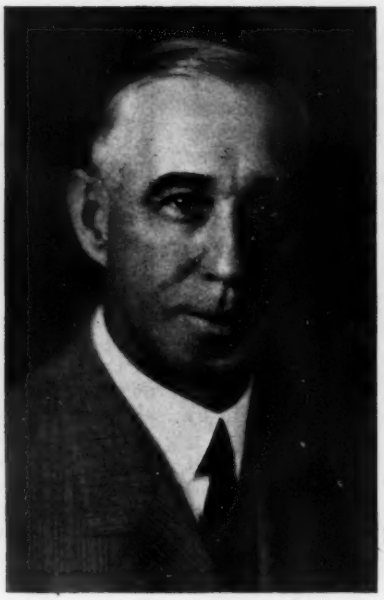

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FIFTH ANNUAL MEETING OF WESTERN DIVISION

Western Division, American Mining Congress, American Institute And Silver Producers Association Hold Joint Meeting—Interesting Program Presented Covering Economic And Technical Problems—Philip Wiseman, Los Angeles, Elected Chairman

MEETING in the center of our great western mining country during the week of August 22, mining men from the West assembled at Salt Lake City, Utah, for the Fifth Annual Convention of the Western Division of the American Mining Congress, and considered important questions affecting the present welfare and future development of the metal industries.

The meeting was called to order by Louis S. Cates, Vice President and General Manager of Utah Copper Company, who said:

"Utah is an interesting mineral field. Much of it is already known to many of you, and we hope that others will take the opportunity to learn more about it.

"Our program for the week includes meetings conducted by the American Institute of Mining and Metallurgical Engineers, by the American Silver Producers Association, by the General Tax Committee of the American Mining Congress, and by the Western Division of the American Mining Congress.

"Today's sessions are devoted to the Western Division. The Division is a representative body, consisting of the elected members from each of the eleven Western metal mining states. It had its inception at an informal conference of mining men at Denver and was formally organized at Salt Lake City in June, 1923. This is its fifth annual meeting.

"The Western Division, in accord with the traditions and practices of the American Mining Congress, has concerned itself with the practical, economic problems of its field. It is a cooperative organization, with no salaried officers or employes, and has functioned so effectively in connection with matters of common interest to all its member states that it has become the recognized medium through which the non-ferrous metal membership of the American Mining Congress expresses its views to the parent body.

"When this group of men get together, representing, as it does, these mining and metallurgical organizations, it will be of interest to point out just what this means to the nation's business.

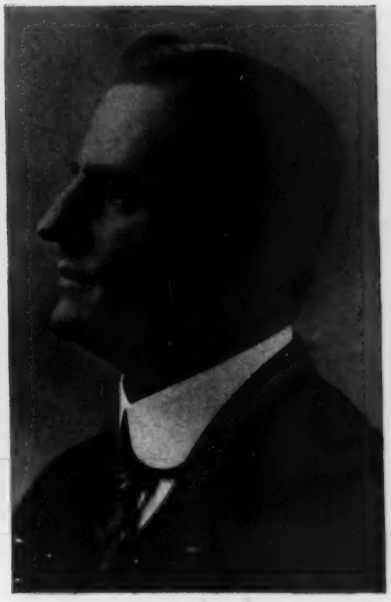
"First of all it represents the value of the mineral resources of the United States, which, each year for the past four years, has had an approximate value of $6,000,000,000.

"Many of you, perhaps, are not familiar with the Inter-state Commerce Commission's report on the movement of freight. For the quarter ended March 31, 1927, the total number of tons of freight originating on the class 1, steam railways, amounted to 300,000,000 tons. Of this total amount, the products of mines was 166,000,000 tons, or 55 1/3 percent of original freight. Total freight carried by the class 1 steam railways, all roads, amounted to 568,000,000 tons, of which the products of mines furnished 309,000,000 tons, or 54 2/5 percent of all the tonnage handled in the United States. Remember that these figures are for the first three months only of the present year.

"In 1923 there was produced 570,000,000 short tons of bituminous coal, a figure exceeded but twice in the history of the industry. In the same year there was produced 67,000,000 tons of coke, which is greater even than the record set in 1918. Do you realize that in 1925, 764,000,000 barrels of petroleum was produced in the United States, which was more than double the production of our country in 1918, and, compared with the figures of 1920, was nearly 70,000,000 barrels more than the entire world produced during that year? Do you realize that the United States produced more than half of the world's copper, 40 percent of the world's lead, 46 percent of its zinc, and over 51 percent of all the pig iron? In 1926 there was produced over 39,000,000 long tons of pig iron, exceeding the production of all war years, and exceeded only by the record of 1923. Steel ingots and castings amounted to more than 48,500,000 long tons in 1926, which quantity has never been exceeded, and this represents 53 percent of all the

P. C. Knapp

Jesse F. McDonald



Robert I. Kerr

ingots and castings produced in the entire world.

"While the United States is not only the greatest producer of mineral products in the world, it is likewise the greatest consumer. Metal consumption per person in the United States in 1926 was 15 pounds of copper, 13 pounds of lead, and 10 pounds of zinc, whereas the figures for Great Britain are 7, 12 and 8, in the order of the metals mentioned; France follows with 6, 5 and 6; and Germany with 6, 5 and 5. It will be noticed, therefore, that the United States consumes per person more than double the amount of copper, per capita, than the other leading nations; about the same amount of lead as is used in Great Britain, and more than double that of France or Germany; and in zinc nearly twice as much as any of the three nations mentioned.

"This short resume, in a measure, will give you some idea of the industry, the problems of which we are assembled to discuss. The mineral resources represent the backbone of our nation, without an adequate supply of which no nation can long endure.

"These figures are brought to your attention to impress upon you the magnitude of the task that we of the mining profession have before us, and to ask that all present give serious thought and consideration to the problems presented at this regional conference. It is not only of interest to those of us immediately affected, but bears directly on the prosperity of the nation as a whole.

"I appreciate fully the distinction shown by asking me to preside at this session, and I assure you that I will do all in my power to cooperate in these proceedings."

The Honorable C. Clarence Neslin, Mayor of Salt Lake City, extended a hearty welcome to the delegates. Representatives of the varous mining districts presented short talks on mining conditions throughout the West. The general tenor of these talks indicates that while the industry is slowing down production on account of the low price of silver, lead and zinc it is staging a comeback which will show a material increase in production during the coming months. All were unanimous that there should be no interference with the mining schedule in the Fordney-McCumber tariff bill and that the industry should receive both national and state cooperation in solving its problems.

Electric shovel operations at the Utah Copper Company was presented by Mr. R. J. Corfield. This paper appears in full in this edition of THE MINING CONGRESS JOURNAL.

Russell G. Lucas, Attorney for Utah Copper Company, presented an interesting paper on the principles of workmen's compensation; in part, Mr. Lucas said:

PRINCIPLES OF WORKMEN'S COMPENSATION

THE topic assigned me is as broad as the doctrine of salvation, and has almost as many ramifications. Necessarily only a few of the most fundamental aspects of the subject can be touched upon in the short time alloted me.

"The purpose of workmen's compensation legislation is to eliminate the multifarious evils incident to our former system of damage suit litigation. The three thoughts underlying this class of legislation are:

"(1) The act was passed in the constitutional exercise of the state's police power to promote the public good.

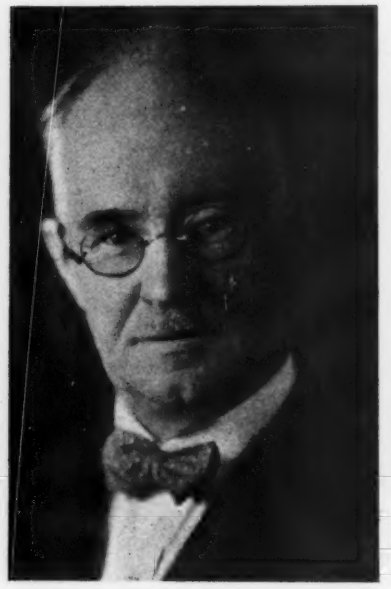
"(2) The act is a tri-partite trade between the employers, the employes, and the general public, wherein each has surrendered and must continue to forego some right, interest, and advantage for the mutual common good.

"(3) The theory of the act is that the pecuniary loss consequent upon industrial accidents is a legitimate charge upon the cost of production, to be borne in the first instance by the industry, and to be ultimately distributed and liquidated in the steps ending in public consumption.

"If those three great and controlling facts are constantly kept in mind in framing and administering compensation legislation, they will effectually solve the problems presented, will operate to obviate attempted injustice, and will assist in repelling shameless selfishness.

"There is almost constant pressure exerted to increase the percentage of wage allowed as benefits according to the statutory scale, and to increase the fixed maximums under established percentages. Such attempts are invariably sought to be supported not by economic facts, not by reasons addressed to the intelligence, but by appeals to emotional sympathy. Need is the sole keynote of the song. There are several answers to ill-considered efforts of that character.

"To increase the miximum without in-



M. B. Tomblin

A. P. Ramstedt

Ravenel Macbeth

creasing the percentage is obviously aimed at helping only the high wage earner, the one who least requires assistance, and the one who already invariably receives the established maximum. It does not benefit one iota the low wage earner whose need is the greatest, and who falls short of the maximum benefits. To help the one and ignore the other would be an obvious injustice. There never can be a logical increase of the maximum without a percentage increase being warranted by economic considerations.

"Individual or family need can never be a just measure of compensation benefits. They are entirely too variable to admit of general admeasurement by any fixed rule. The industry can not control, and is not legally or morally responsible for, such need. The wage loss is all that is justly chargeable to the industry, and that loss must be divided upon the basis of economic and moral standards into which individual need can never enter as a justifiable factor. Hard cases, considered individually, are the quicksands of every system of law. Safety lies only along the path of general rules designed to work out the highest good of the greatest number. The underlying theory of this legislation contemplates that the laborer must bear a just share of the accident loss, and that principle is not to be crucified on the cross of individual necessity.

"The laborer must bear his just proportion of the loss for its moral effect. If the disability benefit is unduly increased, it is an encouragement to carelessness; it puts a premium on idleness and thriftlessness; and is a direct temptation to fraud, imposition, and malingering. Over-insurance, from whatever cause or causes, source or sources, is universally recognized as dangerous in its tendencies, and as contrary to public policy. The laborer who acquiesces cheerfully in a co-insurance clause in his fire policy, the form of which is prescribed by statute, can not consistently object to the co-insurance principle written into the Compensation Act. The basic moral concept is the same.

"The laborer must bear his just share of the burden for its legal effect. In imposing upon the industry liability regardless of and in the absence of fault, the act took from the employers more legal rights numerically and historically than it did from the employes. The laborer can not properly escape paying his part of the consideration for the bargain. He can not in this transaction, any more than in any other transaction of life, expect to get something for nothing. Only the professional gambler expects or hopes for such a boone; and human experience demonstrates that he is doomed to disappointment.

"The laborer must help carry his part of the economic burden imposed upon the industry, both from an absolute and a relative standpoint. Those who see the problem solely through the inverted end of the opera glass of the laborer's need should pause to remember that what the laboring man needs most is a job. If there were no industries there would be no compensation legislation. The industry and the laborer must prosper or perish together. Each is indispensable to the other. Every compensation increase must apply to every industry in the state alike, regardless of whether any particular industry happens to be mak.ng money or is on the verge of bankruptcy. Industries that are skating on thin ice can not survive the increase. Industries that are earning a reasonable return on the capital invested are going to safeguard and maintain that return, and an increase of cost in one direction must necessarily be met by a decrease in another direction. There is a limit beyond which compensation costs can not go. There must be a margin of safety between costs and legitimate profits, and unjust and undue compensation increases must inevitably be reflected in reduced wage scales. The man with a dollar is just as much entitled to protection as the man who is trying to get it away from him. If the enlightened wisdom of the legislature will not protect him, he must and will protect himself by means within his own grasp. The law of self-defense applies to financial as well as physical relations. This law is humanitarian in its ideals, but must be reduced to the practical in its application.

"In theory, compensation costs are to be passed on to the ultimate consumer. When the reason for a rule fails, the rule fails with it. When a reason is impossible of application, the rule is likewise so. Most of our western industries of importance and magnitude are compelled to find their markets beyond the territorial confines of their respective states, and there compete with similar industries in other states, and even in foreign countries. The burden of increased compensation costs can not be passed to consumers in other states and countries, unless our eastern and foreign industrial rivals are also subjected to a corresponding burden. Our

C. B. Lakenan

John M. Sully

Joseph Woodbury

western industries can not successfully meet extra territorial market compensation if their load is made too heavy, particularly in the face of the handicap under which they labor in having to absorb transcontinental transportation rate charges.

"A careful comparison of compensation legislation throughout the Union will demonstrate that the Western States (despite their geographical handicaps, their meagre population, their idle resources, and their financial limitations) have dealt not only fairly but even generously with the laboring man. There are 31 states in the Union which pay less in compensation benefits than do, respectively, Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Washington, Wyoming, or Utah. Is there anything in western economic conditions that will justify compelling western industries to carry the peak load of the campaign for compensation increases? Surely not. Comparatively, their burdens are already respectively too high.

"Let it also be remembered that what the West most needs today is a further development of their now idle resources, an encouragement to the influx of capital, and more and larger pay rolls; and not legislation that will turn the investing public to other localities.

"Those thoughts also answer the agitation for the abrogation of the waiting period, and the tendency to graduated disability and death benefits scaled on a percentage basis as measured by relative individual and family needs. This legislation is measuring out justice and not charity. It is dealing in legal and moral rights, not in generosity.

"Labor is everywhere seeking to have occupational diseases included in the Compensation Act. There are only 12 states which now include such diseases. There are many reasons why they should be excluded.

"They would increase the compensation cost burden enormously.

"The design of this legislation was to provide a substitute for the common law accident liability of industry. There was then no thought of legal liability for occupational disease, and ought not to be now.

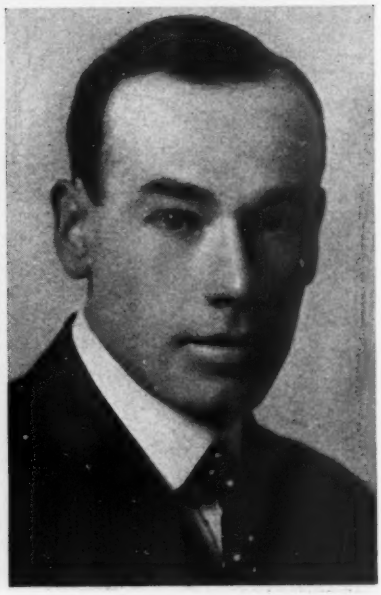
"The inclusion of disease opens wide a door to fraud, imposition, and deception. But a few years ago there were only a dozen known occupational diseases. Unscrupulous doctors have to date discovered or manufactured over 500 such diseases, and the end is not yet in sight. It is practically impossible to ascertain with any reasonable precision the exact time or place when such disease was contracted. Not only is the onset darkened with doubt, but the contributing circumstances are always under the cloud of uncertainty. The progress of the disease is always more or less speculative. In short, industry, in such disease cases, is practically prostrate before the medical Pontius Pilate whose deity may be the dollar.

"Moreover, it is impossible to apportion the degree of progress the disease may have attained under different successive employers.

"Under a disease law, rigid medical examinations should be, must be, and will be resorted to for protective purposes; and the labor scrap heap will be increased immeasurably.

"Another effort to increase industry's compensation burden is instigated and supported not by labor but by the private stock insurance companies. They seek to force the support of state compensation institutions and tribunals to paid out insurance premiums. Why? The answer is clear. They desire the employer who insures in a state fund to be under such added expense to offset their general office overhead and acquisition expenses charged into their private insurance premiums, so that they may maintain high premium rates, and increase them, and still compete on a premium cost basis with the state fund. This attempt on the part of the insurance companies is unwarranted in principle. This law is for the general public good. It saves the time and expense of courts, jurors, witnesses, and parties. The expense of administering this law should be paid out of the general funds in the state treasury just as, and for exactly the same reasons as, the expense of other administrative bodies and tribunals is so paid. Moreover, the theory of compensation insurance premium rates, in some respects, is manifestly unjust.

"Compensation insurance premium rates for all the states of the Union are fixed by one central body, known as the National Workmen's Compensation Service Bureau, an organization controlled absolutely by the insurance companies. If time permitted it would be interesting to discuss their theories of national experience, business cycles, catastrophe contingencies, etc. Statistics show that out of every dollar you pay the insurance companies in pure premiums they expend 66 2/3 cents on



Robert M. Betts

themselves and pay your laborers only 33 1/3 cents. They charge you $2 for the privilege of paying out one of your dollars. Another fact may interest you. Seventeen and one-half cents out of every dollar you pay the insurance companies in premiums is paid out to local commissioned brokers and agents as an "acquisition expense" for soliciting the business. The employers of this nation pay out about $30,000,000 a year for that totally unnecessary service. Why unnecessary? Because there is no competition in rates. They are the same for every company and are fixed by a central bureau. No persuasion is needed to induce the employer to take out compensation insurance. He has no choice about it. The law compels him to do it. To the disinterested outsider there is a touch of humor in the employer paying an insurance broker 17½ percent of his pay roll premium for inducing him to purchase something the law of the land obligates him to buy. This 'acquisition expense' explains largely why the state fund can sell protection at a differential of 20 percent under the private stock insurance carriers.

"In conclusion, gentlemen of the mining fraternity, see to it that your legislators and industrial commissions are neither misinformed or misguided. Whip the soap-box orator by placing cold facts in the hands of the man on the job. Remember:

"'New times demand new measures and new men.
The world advances and in time outgrows
The laws that in our fathers' days were best.
And doubtless after us some purer scheme
Will be shaped out by wiser men than we,
Made wiser by the steady growth of truth.'"

More Funds Urged for Bureau of Mines and Geological Survey

A. G. Mackenzie, secretary of the Utah Chapter of the American Mining Congress, presented an interesting review on the provisions of mine tax laws, which appears elsewhere in this issue.

F. H. Smith, Bunker Hill and Sullivan Mining Company, presented a resolution for the consideration of the convention on appropriations for the Bureau of Mines and the United States Geological Survey, calling attention to the fact that the estimates of the chiefs of these bureaus had been substantially cut by the Director of the Budget, thereby curtailing much of the important work of these two agencies for the mining industry.

Dr. Francis A. Thomson, dean of the Idaho School of Mines and Director of the State Bureau of Mines and Geology, speaking in regard to the resolution, pointed out that the total appropriation for the U. S. Geological Survey and the U. S. Bureau of Mines for 1927 amounted to only three and one-half million dollars, whereas the appropriation for the United States Department of Agriculture for the same year amounts to one hundred and twenty-eight million dollars, a proportion wholly unfair to the relative importance of the two industries. Dr. Thomson stated that the annual agricultural production of the country is approximately twelve billion dollars and quoted the figures presented by Mr. Louis S. Cates at the morning session showing that the mineral production of the country in round numbers is six billion dollars. Per capita, this shows $109.00 of agricultural production and $47.00 of mineral production. The Federal Government expends $1.00 for every $101.00 produced in agriculture for the support of that industry, but expends only $1.00 for every $1,622.00 produced by the mineral industry in support of research in geology, mining and metallurgy. In other words, on the per capita basis, Congress appropriated for 1927 thirty-five times as much for agriculture as for mining, and on the production sixteen times as much. (*The resolutions adopted at the convention appear on page 737 of this issue.*)

A. I. M. E. Session

The program of the American Institute of Mining and Metallurgical Engineers occupied two days of the meeting and was devoted exclusively to the discussion of technical mining problems, particularly the development of flota- and especially of selective flotation and

Bruce C. Yates

the resulting benefits to the metal mining industry and to the state and the nation. Several of the papers presented appear in full in this issue.

The opening session, presided over by J. O. Elton, Manager, International Smelting Company, Salt Lake City, featured a discussion of the economic results of the development of flotation and its relation to mining, smelting and to the state.

Ernest Gayford, of the General Engineering Company, Salt Lake City, defined flotation and gave a short resume of its development. The treatment of complex lead-zinc ores by selective flotation was cited as an example of the beneficiation of ores which were worthless prior to the development of flotation. As a result there are now seven plants in Utah producing high grade lead and zinc concentrates. Of these, two also produce an iron concentrate and one treats a zinc-copper ore.

Mr. Gayford stated that no other development in metallurgy had caused so great a change in such a short time and predicted that the next five or ten years would see as great an advance as has been made in a like period in the past.

Frank Wardlaw, Superintendent at the Utah-Delaware mine, gave a short sketch of the rehabilitation of that property as a direct result of the development of selective flotation. In 1924 the mine was on the point of shutting down and it looked as though that shut-down might be permanent. The mill at Tooele was converted into a lead-zinc mill and was to treat a moderate tonnage of this type of ore which had been previously developed. This led to further develop-

ment as a result of which the mine is now making a daily production of

525 tons ore containing 10% lead and 6% zinc;

50 tons ore containing 25% lead and 6 oz. silver;

125 tons ore containing 4.5% copper.

Mr. Wardlaw interpreted this activity in the terms of consumption of Utah-grown farm products by the community of 2,500 people directly dependent on the Utah-Delaware mine for their livelihood.

Paul Hunt, manager of the Park Utah Consolidated Mines, outlined the part played by selective flotation in the present prosperity of the Park Utah mine. Prior to the expiration of the Pittman act the Park Utah had mined 94,000 tons of silicious silver gold ore which has yielded a profit of $15 per ton. With the drop in the price of silver this profit was wiped out. The mine contained a quantity of lead, zinc, silver, gold ore of a gross value of $20 per ton. Flotation tests were made and contracts entered into with the International Smelting Company for the treatment of this ore. As a result profitable operation on an increasing scale has continued. In 1926 production was 165,000 tons, and in 1927 it will be approximately 230,000 tons.

E. E. Barker, Engineer of Mines for the Utah Copper Company, showed how flotation had increased the scope of operations and lengthened the life of that enterprise. The ore of the Utah Copper Company was first treated entirely by flotation in 1923. Prior to that, mill extraction was 65 percent and the ore reserves were estimated at 400,000,000 tons. At the present time, mill extraction is better than 90 percent and material containing as low as .5 percent copper is treated. Ore reserves have been recalculated and are now estimated at 600,000,000 tons, giving a life of 45 years.

W. H. Eardley, manager of the Smelter for the United States Smelting, Refining and Mining Company, Richard A. Wagstaff, Assistant Manager, American Smelting and Refining Company, B. L. Sackett, Superintendent, International Smelting Company, and A. B. Young, assistant manager of the International Smelting Company, discussed the effect of flotation on the various phases of lead and copper smelting. They showed how the development of flotation had passed many trials and tribulations on to the smelter. The change in the material treated had necessitated the installation of much new equipment for weighing, conveying, sintering and bag-house installations. In general it had tended to decrease the tonnage to be handled by the smelter and as a result had curtailed smelter operations. It had also increased the difficulties in handling materials.

F. W. Maclennan

On the other hand, the elimination of gangue by flotation and the production of iron concentrates containing some gold and silver makes possible the treatment of much silicious oxidized lead ore that could not previously be treated at a profit. And it conserves at least 25,000 tons of zinc that previously passed into the slag. The value of this alone is $800,000 to $900,000 per year.

Paul Billingsley, Consulting Geologist, stated that flotation has so broadened the field for the geologist that the economic geologist, especially in the Inter-Mountain District, is now in the strongest position that he has ever been in.

W. Mont Ferry, Managing Director of the Silver King Coalition Mines Company, gave an imposing array of statistics to show the great benefits to Utah and the nation resulting from the development of selective flotation. Six or seven years ago mining in Utah was at a low ebb, partly because of the past war depression, but largely because the supply of direct smelting ore was being depleted. The development of flotation has changed the entire aspect of the mining situation in Utah and the industry is now in the best condition in its history.

The second session, presided over by Galen H. Clevenger, consulting metallurgist of Boston, was devoted to a discussion of the theory of flotation and the flotation practice at various concentrating mills. This discussion was continued at the Wednesday sessions.

At the Wednesday morning session. E. De Golyer, President of the American Institute of Mining and Metallurgical Engineers, was introduced and gave a short outline of the growth of the mineral industries and their very great importance in our present day civilization.

Tax Meeting

A meeting of the General Tax Committee of the American Mining Congress added interest to the convention. A report was made and discussed on the progress of the investigation of the Federal internal revenue system by the congressional joint committee, and suggestions were made concerning the work of the Tax Division of the American Mining Congress.

The committee on resolutions was composed of the following representatives: W. B. Gohring, Arizona; G. N. Bjorge, California; J. F. McDonald, Colorado; Jerome J. Day, Idaho; Daniel Kelly, Montana; J. F. Woodbury, New Mexico; A. W. Strowger, Oregon; R. C. Wayland, South Dakota; D. D. Moffat, Utah; F. H. Smith, Washington.

Resolutions were presented covering the manganese tariff, increased appropriations for the Bureau of Mines and the United States Geological Survey and leasing of oil shale lands.

A meeting of the directors of the American Silver Producers Association was held at the Hotel Utah, Friday, August 26, where ways and means were considered to improve the price of silver.

At a luncheon of the Board of Governors of the Western Division the following directors were elected for the year 1928:

Arizona: F. W. MacLennan and W. B. Gohring.

California: Philip Wiseman and Robert I. Kerr.

Colorado: Jesse McDonald and M. B. Tomblin.

Idaho: A. P. Ramstedt and Ravenel Macbeth.

Montana: W. B. Daly and C. L. Berrien.

Nevada: J. C. Kinnear and Henry M. Rives.

New Mexico: J. M. Sully and J. F. Woodbury.

Oregon: Robert Betts and A. W. Strowger.

South Dakota: B. C. Yates and R. C. Wayland.

Utah: D. D. Moffat and A. G. Mackenzie.

Washington: Frank M. Smith and Leon Starmont.

The program of entertainment arranged by the local organizations was especially interesting, including a reception on Monday evening, August 22; a luncheon at the Salt Lake Country Club and Alpine Scenic Tour; the showing of the Bureau of Mines motion picture film, "The Story of Copper"; a reception at the home of Governor and Mrs. Dern; an organ recital at the Mormon Tabernacle; and a dinner dance at Saltair Beach, Great Salt Lake.

METAL MINE TAX LAWS OF WESTERN STATES*

A Brief Summary Of The General Provisions Of Laws Pertinent To Taxation Of Metal Mines In The Eleven States That Constitute The Western Division Of The American Mining Congress

By A. G. MACKENZIE †

THIS paper is merely a brief summary of the metal mine tax laws of the 11 states that constitute the Western Division of the American Mining Congress.

It undertakes to give only the general provisions of the various laws, without comment or comparison and without consideration of the fact that partial valuations apply to all property in some of the states. No reference is made to license taxes, franchise taxes, inheritance taxes, state income taxes, or other special taxes that apply to all property or to all business operations in some of the states.

These omissions are made to keep the paper within the desired length and scope.

ARIZONA

Arizona has no mine tax laws. The valuation of mines for purposes of taxation is fixed by the state tax commission. The commission has divided productive metal mines into nine classes and capitalizes the net earnings over a period of years at various rates to arrive at the valuation of the mines in the different classes. The capitalization factors employed range from 15 to 30 percent. Most of the productive mines are put in the 15 percent class. Non-productive mines are valued by county assessors on the same basis as other property. Deduction of the cost of extraction, reduction, transportation, treatment and all general expenses, including taxation and administration, is permitted in the computation of net earnings of productive mines.

CALIFORNIA

The California law provides for the valuation of mines for taxation purposes on the same basis as real estate. Valuations are made by the county assessors. The practice is not uniform, but many assessors take the preceding year's net proceeds and add to that a valuation of the ground as compared with adjoining or adjacent ground and the value of machinery and improvements. Undeveloped properties are usually valued at $5 an acre.

COLORADO

The Colorado law provides that productive non-ferrous metal mines shall be assessed on one-fourth of their gross proceeds or on their net proceeds, whichever is greater, with the valuation of their machinery and improvements added. All mines that have an annual gross output of $5,000 or more are classed as productive. Deductions in computation of net proceeds include cost of extraction, transportation, reduction, treatment, sale and workmen's compensation. Non-productive mines are assessed on the basis of actual value, not to exceed the valuation per acre placed on the lowest productive mine in the same locality. Iron mines are assessed on the same basis as other property. Valuations are set by the county assessor.

IDAHO

The Idaho law provides that all mines shall be assessed on their net proceeds, if any, at full value, on machinery and improvements at full value, and on surface ground at the price paid the United States Government therefor when used for mining purposes; when otherwise used at full value for such other use. Deductions permitted in computation of net proceeds include the cost of extraction, transportation, reduction, treatment, sale, machinery purchased in the taxable year, supplies and repairs. Valuations are made by the county assessor.

MONTANA

Montana classifies property for purposes of taxation. Net proceeds of mines are assessed at 100 percent, machinery and improvements at 30 percent of actual value. Surface ground of mining claims is assessed at the price paid the United States Government therefor when used for mining purposes; when otherwise used, on the basis of such other use. Deductions permitted in the computation of net proceeds include the cost of extraction, transportation, reduction, treatment, sale, repairs, construction done and supplies and machinery purchased in the taxable year. There is also an additional tax in the form of a gross proceeds metal mines tax, which begins with one-fourth of 1 percent of the gross value of the annual output of mines that produce more than $100,000 a year and increases to 1 percent of the gross value of the output of mines that produce more than $500,000 a year.

NEVADA

Nevada values patented mining claims at $500 a claim (which valuation is not made when $100 annually or more a claim is expended in work on the claim) and on the net proceeds, which is popularly called the "bullion tax" in Nevada. The "bullion tax" is payable quarterly. Deductions permitted in computation of net proceeds include cost of extraction, transportation, reduction, treatment, sale maintenance and repairs and depreciation at the rate of from 6 to 10 percent per annum on machinery and equipment. Valuations are made by the county assessor.

NEW MEXICO

The mine tax law of New Mexico permits the application of two methods of mine valuation for taxation purposes. The first method provides for the assessment of net proceeds and physical property generally along the lines followed in other western mining states. The second method provides for the so-called "physical valuation" plan, and is the one that was adopted by the state tax commission, which makes all the mine assessments. After the passage of the present law, the state tax commission employed a well-known engineer to place valuations on the mines of the state and has published the report of his appraisal. The factors and methods employed in the establishment of the "physical valuation" of the mining property of a state are too involved and too diverse for summation here. Mine operators are required to make detailed annual reports of operations, under oath, to the state tax commission, from which the commission determines the valuations.

OREGON

Mining property is assessed by county assessors, in accordance with their judgment as to its value, on the same basis as other property.

SOUTH DAKOTA

South Dakota has no mine tax law, and mines are assessed by the county assessors in accordance with their judgment as to value of the property.

UTAH

The surface ground of metalliferous mines in Utah is assessed at $5 an acre when used for mining purposes; when otherwise used in accordance with such use. To this assessment is added an amount equal to three times the net annual proceeds and the full value of machinery and equipment. Deductions permitted in computation of net proceeds include cost of extraction, transportation, reduction, treatment, machinery purchased and construction done in the taxable year, local taxes, workmen's compensation, office and clerical expenses and salaries of em- (*Continued on page* 721)

* Address delivered before Annual Meeting of Western Division of The American Mining Congress, Salt Lake City, August 22-25, 1927.

† Secretary, Utah Chapter, The American Mining Congress, Salt Lake City.

View of 500 Level Surface Plant, United Verde Mine, Jerome, Arizona

MECHANIZATION AT THE UNITED VERDE MINE

Ore Bodies Described—3,000-Ft. Level Being Developed—Pillars Removed By Top Slicing—Six Different Methods Of Stoping Necessary—Timbering Costs Detailed—Drilling Speed And Blasting Practice Outlined—Equipment And Operating Costs Summarized—Bonus System In Use

By C. E. MILLS*

THE United Verde Mine is located at Jerome, Yavapai County, Arizona, on the great southern escarpment of the Arizona plateau which forms the northeast side of the Verde Valley. The United Verde Smelter is located at Clarkdale, on the Verde River, four miles north of Jerome and 1,700 feet lower in elevation. The two towns are connected by the standard gauge Verde Tunnel and Smelter Railroad, a subsidiary of the United Verde Copper Company. At Clarkdale, it connects with the Verde Valley Branch of the Santa Fe.

The property was first located in 1877 and was worked intermittently from that date until 1888, when Senator W. A. Clark, of Montana, obtained an option on the property and purchased control in 1889. Since that time, the United Verde has produced 13,682,000 tons of ore, 663,197 tons of copper, 22,664,300 ounces of silver, and 641,980 ounces of gold. The production record for the year 1926 was 1,285,461 tons of ore, 56,019 tons of copper, 2,306,061 ounces of silver, and 61,003 ounces of gold.

* Chief Engineer, United Verde Copper Co.

ORE DEPOSITS

The ore bodies are of the schist replacement type, the mineralization having been aided by the concave margin of the United Verde Diorite which forms a steeply pitching trough and localized the solutions in their upward course. The main sulphide mass consists of a huge pipe-like body extending from the surface to the lowest levels and dipping steeply to the northwest.

The commercial orebodies occur either along the iron-schist contact or within the body of the pyrite mass. On the upper levels, the ore zone is approximately 600 by 1,100 ft. and lenticular in shape. On the lower levels the mineralization is confined more closely to the iron-schist contact and the ore bodies extend about 1,000 ft. along the contact and vary from a few feet to 250 ft. in width.

The major oxidized zone extends to the 160-ft. level, and the ore above this horizon has been removed by shovel operations which were started in 1919 for the purpose of mining the upper portion of the mine, which has been on fire since 1894.

EXTENT OF DEVELOPMENT

Underground operations extend from the 300 level, at an elevation of 5,207 ft. to the 3,000-ft. level, at an elevation of 2,528 ft. The mine is served by two shafts. No. 5 shaft extends from the 3,000 level to the 800 level and is used exclusively for hoisting ore from all levels below the 900; No. 6 shaft is a service shaft and extends from the 400 level to the 2,400 level. Both shafts have underground hoist rooms.

The 3,000 level is being developed from a winze sunk from the 2,400 level pending the completion of that portion of No. 5 shaft below the 2,400 level. The mine is developed by approximately 40 miles of workings, all of which are accessible and open.

Underground Mining

Mining Methods

During the year 1926, the tonnage was produced by various mining methods as shown in the following tabulation:

Shovel and open pit (Smelted)		490,166	
Underground Mines:			
	Tons		Percent
Development	28,479		3.6
Cut-and-fill	441,971		55.6
Square set	125,470		15.7
Top slice	98,114		12.3
Underhand	57,872		7.3
Shrinkage	43,389	795,295	5.5
Total tonnage		1,285,461	100.0

The general conditions that govern the selection of a mining method are the size and shape of the ore body, grade and character of ore, character of the walls, and cost of materials. Other important considerations are the necessity for safe and efficient working conditions for the men, fire hazard, complete extraction of ore, flexibility of stope development, and ease of sorting waste. The best mining method for any block of ground is the one which will give the lowest total cost per pound of copper and the greatest amount of safety for the men.

Shrinkage stoping is one of the cheapest underground mining methods, but is applicable to only a few of the ore bodies in the United Verde mine. In the past, the inclined cut-and-fill method has been used but very little because of the tendency of the heavy sulphide to shatter well ahead of the face blasted and the attendant danger of working under the brow. The saving effected in mucking and the more pronounced saving in handling waste are largely offset by the higher cost of handling timber and steel and erecting bulkheads on an inclined slope as compared with the horizontal cut-and-fill method.

The horizontal cut-and-fill method overcomes most of the objections to the preceding methods, and is used for mining the greater portion of the ore bodies.

Square set mining is resorted to in the upper levels where the ground is badly fractured and heavy, and for removing floor pillars and vertical pillars between stopes.

The top slice method was resorted to in 1924 in removing a floor pillar in weak ground over a large stope on the 1,650 level. This method has proven so satisfactory that its use is being extended to both floor and vertical pillars.

The underhand method is used only in mining small vertical extensions of ore bodies which are found to extend below the floor on which such downward extensions are first developed. It is also applicable to floor pillars where the stope directly above has been mined by the shrinkage method and remains unfilled.

Stoping

Six different stoping methods are used at the United Verde mine in extracting the underground ore, viz: Cut-and-fill, square set, top slice, underhand, shrinkage, inclined cut-and-fill. It is not within the scope of this paper to present the various mining methods in detail, but merely the pertinent mechanical features of stoping in general.

Chute Construction

Fig. 1 gives a detail of the standard ore chute used for all stoping methods. Chute sides, bottoms and angle pieces

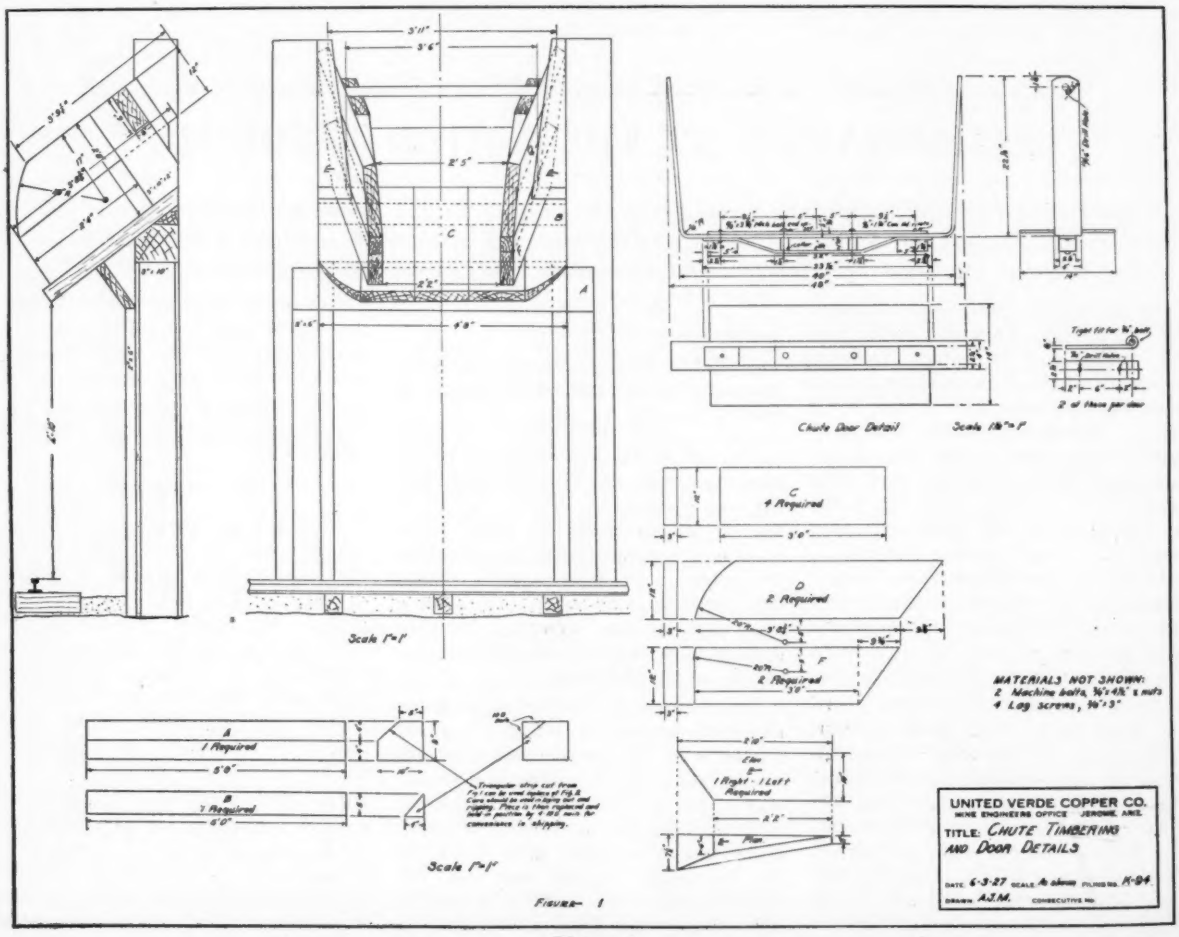


Figure 1

are framed at the mill. The steel gate, as shown in this same figure, is easily made up and has given very good service.

Chute cribbing is of native pine, 5 in. by 8 in. by 5 ft. for the single cribbing, and 5 in. by 8 in. by 10 ft. for the double cribbing where a manway and chute is carried. The ends are dapped 1 in. and spiked with 80-D spikes. The outside is scabbed with used lagging or flooring and the inside lined with 4-in. native pine.

Fig. 2 shows this type of chute construction. Chutes are spaced approximately 25-ft. centers wherever possible, and are offset to keep within the stope outline. Offset chutes are constructed of 10 by 10 Oregon pine timber, framed in the same manner as square set timbering, and are offset one set horizontally for each floor vertically to give a 45-degree slope. The battering action of the hard iron boulders at the offsets is taken care of by hanging 40-pound rails to take the wear. These rails are 10 ft. in length and hooks are forged at the upper end to hook over the 12 in. by 12 in. chute brace directly above the offset. Batteries of 16-pound rails suspended by chains and eyebolts were first used but resulted in considerable breakage.

Inverted 60-pound rails, spaced to give an 11-in. opening, are used at the tops of all chutes. Native pine spacing blocks, cut to conform to the shape of the rail, keep the rails at the proper distance. These are made up in the carpenter shop and delivered to the various stopes as needed. (Refer Fig. 2.)

Timbering

The cost of timber for the various mining methods is as follows:

Method	Labor	Timber	Total
Square set	$0.42	$0.39	$0.81
Top slice	0.41	0.29	0.70
Shrinkage	0.15	0.19	0.34
Underhand	0.09	0.04	0.13
Cut-and-fill	0.15	0.20	0.35

In stopes where the floor pillar will be removed at a later date, the floor is constructed of 4 by 10 sills overlaid by two layers of 2-in. flooring in 5-ft. 4-in. lengths. Temporary flooring laid on the waste fill for shoveling purposes consists of a single layer of 2-in. native pine flooring. Breakage of this flooring averages 10 percent.

Fig. 3 shows a detail of the square set timbering used in heavy ground and for removing floor pillars. It is purchased in Flagstaff, Ariz., and is framed at the mill to the rough square dimensions indicated. In the open cut stopes, bulkheads are constructed of 10-in. by 12-in. by 6-ft. Oregon pine timber, laid up either two or three pieces to the course. On waste fill, the bulkheads are started on a double layer of flooring, and on solid or broken ore the bulkhead is started directly on the ore.

In top slice work, native pine props are used. These are ordered in 10-ft. lengths and will average 12 in. in diameter. They are delivered to the level and cut to the proper length by a crosscut saw operated by an electric motor. A No. 18 Waugh Spader, air operated ax is used in cutting out old timber, and is especially useful in close quarters where a hand ax can not be used to advantage.

Mucking

In cut-and-fill stoping about 20 percent of the broken ore is pulled directly into the chutes. Up to 15 ft., ore is shoveled into the chutes, and distances over this, wheelbarrows are used. Two-wheeled concrete buggies were tried out in competition with wheelbarrows, but required plank runways and effected no appreciable saving over the wheelbar-

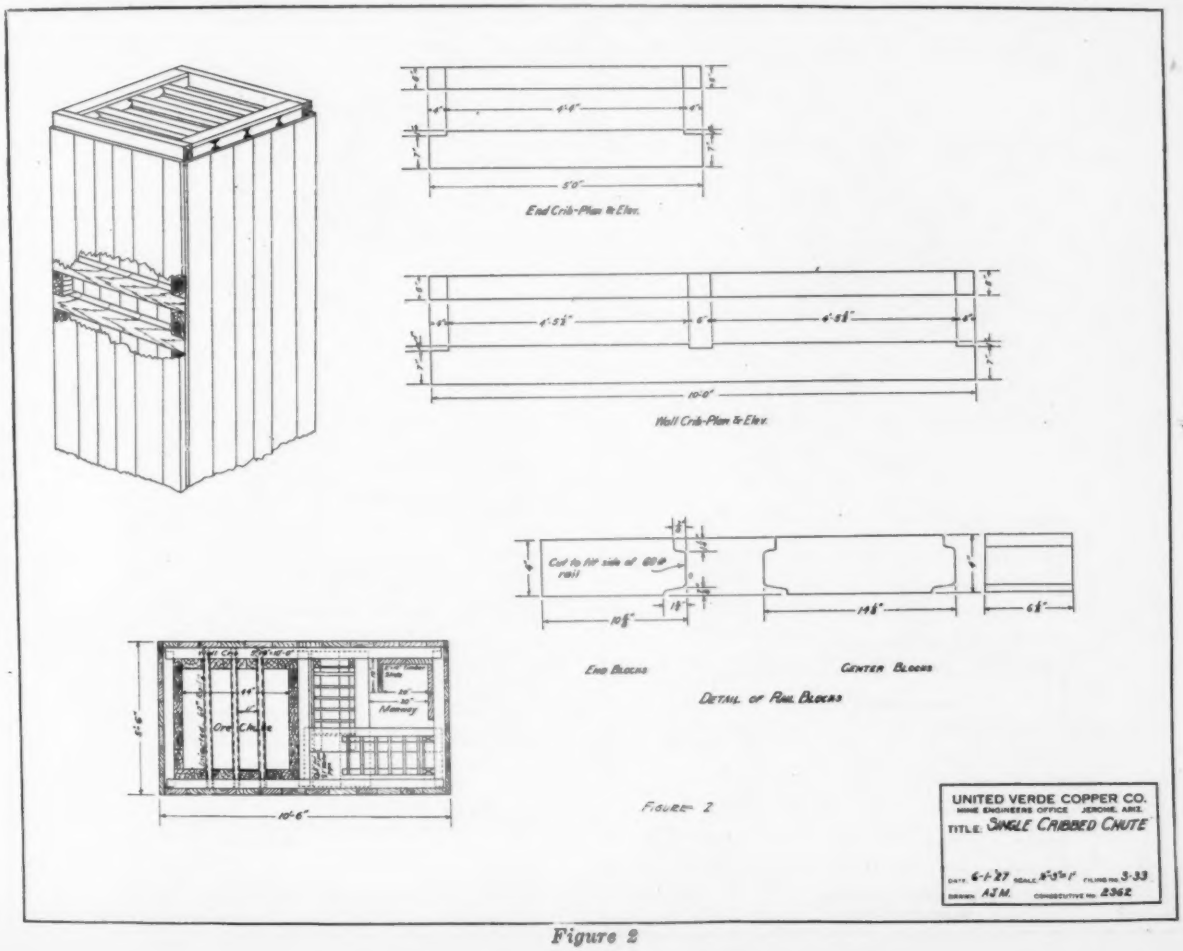


FIGURE 2

Figure 2

rows. No. 2, square point shovels with 42-in. handles are used in all stopes. Shovels with broken handles are sent to the surface and are fitted with new handles. Twelve-pound hammers are used for breaking boulders, and are made from old locomotive tires at an appreciable saving in cost. Muckers are required to wear wire goggles while breaking boulders.

In top slice work, the muck is handled in scoop type dump cars with a capacity of 20 cu. ft. or 1.2 tons of iron. These were designed and built at the company's plant and are equipped with a turntable to permit dumping in any direction. Formerly, 18 cu. ft. standard mine cars were used for tramming in the stopes, but the scoop car, as shown in Fig. 4, has proven more satisfactory. Mechanical loaders have been tried at various times, but with indifferent results. In cut-and-fill stopes, the ore is broken down in 7-ft. cuts, and it has proven impractical to space the holes sufficiently close to break the muck sufficiently small and uniform in size to permit handling with mechanical loaders.

In stopes which are being silled out and where chutes are at infrequent intervals, and also in cleaning up the

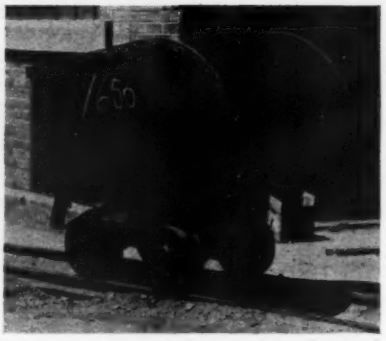


Figure 4—20 Cu. Ft. Scoop Car Used in Top Slice Stopes

broken ore in shrinkage stopes which can not be drawn directly into the chutes, mucking by scraper methods has proven satisfactory. For this work, a Sullivan Turbinair, type HDA, double-drum, column-type hoist is used with a 6-cu. ft. Bagley-type scraper for ore and a 7.5-cu. ft. scraper on waste. Various types of scrapers have been tried out, including the standard hoe-type, but the Bagley has given better service on hard iron muck piles.

The scraper is operated by one man excepting where there are no other workmen in a stope, and in this case he is given a helper. The tonnage per man, or scraper shift, varies greatly and depends upon the local conditions. The bonus rate is usually based on 40 cars (18 cu. ft.) of ore, or 90 cars of waste per scraper shift.

Spreading Waste

Waste raises are driven 6 by 10 ft. in section and spaced so that each raise will serve approximately 3,000 sq. ft. of stoping area. Upon completion of a stope cut, waste is dumped into the waste raise until coned to the back. It is then levelled off and a temporary chute pocket built out of standard 5-in. by 8-in. by 10-ft. cribbing. The waste is then spread by use of 18-cu. ft. standard mine cars and sectional steel track. This track is made up of 16-pound rail riveted to ⅝-in. by 4-in. steel plate ties, and end connections are made by means of a slip-joint tie held in place by a rail spike. Tangent sections are made in 8-ft. lengths and all curves are on 9-ft. radius. Fig. 5 shows a detail of the sectional track.

Scrapers have been found satisfactory for spreading waste in special cases only.

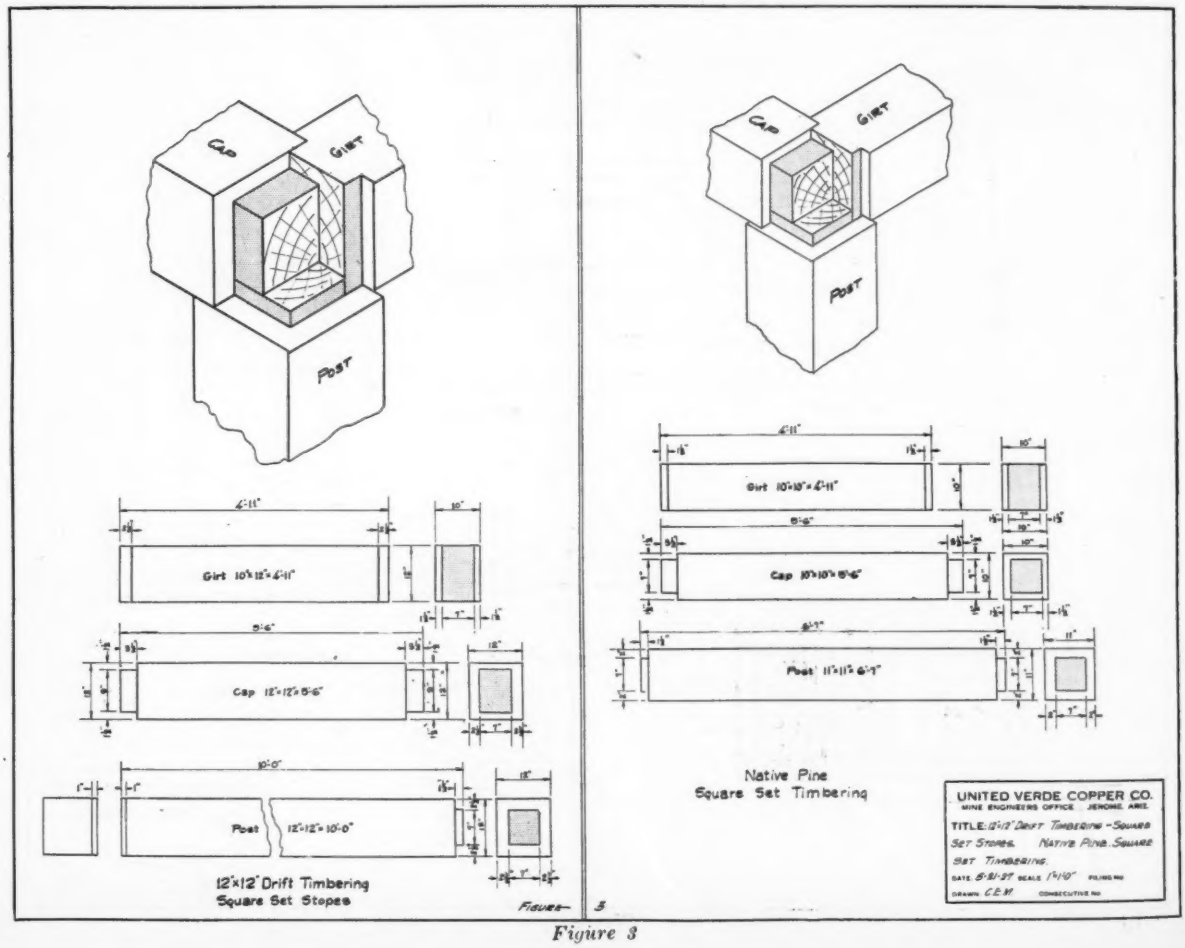


Figure 3

All waste spreading is on bonus, the standard depending on the local condition of the stope and distance to tram. The usual base rate for bonus is 45 cars per man shift in cut-and-fill stopes, and 30 in square set. The average cost per ton of ore for waste spreading is $0.06 for cut-and-fill stopes and $0.09 for square set stopes.

Drilling and Blasting

In cut-and-fill and shrinkage stoping the cuts are taken 7 ft. in height. A fan-shaped round is used, consisting of approximately 10 holes in two rows, drilled to a depth of 9 ft. The drilling speed varies greatly throughout the mine, or from 4 in. per minute in hard sulphide to 18 or 20 in. per minute in the schist stopes. The Ingersoll-Rand 248 Leyner, mounted on a 3-in. vertical column, is used in average ground, and the Chicago Pneumatic CP-6, or the Waugh 7, in the hard iron stopes.

Fifty percent gelatin dynamite in 1⅛ by 8-in. sticks is used in hard sulphide and porphyry, and 35 percent in the schist stopes and for all plugging. A smooth, black finish, cotton-countered safety fuse ("Dreadnaught") is used in 4 and 5-ft. lengths for blockholing, and 7 to 9-ft. lengths for stoping. 6-X caps are used with 35 percent powder, and 8-X with the 50 percent gelatin.

Boulders are blasted during the lunch hour and stope and drift rounds only when going off shift. An electric signal system between levels serves to eliminate danger of blasting by giving a clearance signal from the level above. This is essential because of the danger from SO_2 and H_2S gases formed by blasting in heavy sulphides. All stope miners work on bonus, the rate per machine shift varying from 0.44 sets in the square set stopes to 2.0 sets in the open stopes.

The average cost of drilling and blasting for the various stoping methods is shown in the accompanying tabulations:

All extraction records are kept in sets. This unit in volume is 5.5 by 5.5 by 7.0 ft. The above costs are based on $4.95 for miners, $4.40 for pluggers, powder 9 cents per stick, fuse 60 cents per 100 ft., and caps at 1 cent each.

AVERAGE COST OF DRILLING AND BLASTING IN STOPES
(Year 1926)

	Horizontal Cut-and-Fill	Square Set	Shrinkage	Top Slice	Underhand
Percent ore from stopes	57.6	16.4	5.7	12.8	7.5
Miners per ton	$0.17	$0.30	$0.33*	$0.37	$0.11
Pluggers per ton	0.06	0.17	0.17*	0.04	0.10
Explosives per ton†	0.12	0.10	0.22*	0.13	0.06
Tons per pound of powder	1 6	2.0	1.7	1.5	3.2
Tons per machine shift	16 to 54	11 to 38	16 to 54	13 to 40	20 to 60

†25 percent of explosive charge is for blockholing.
*These costs are based on ore drawn from shrinkage stopes and not on ground broken. Additional charges for compressed air, drills and steel are as follows:

Compressed air	$0.053
Drills	0.046
Steel	0.100
Supplies	0.018
Total	$0.217

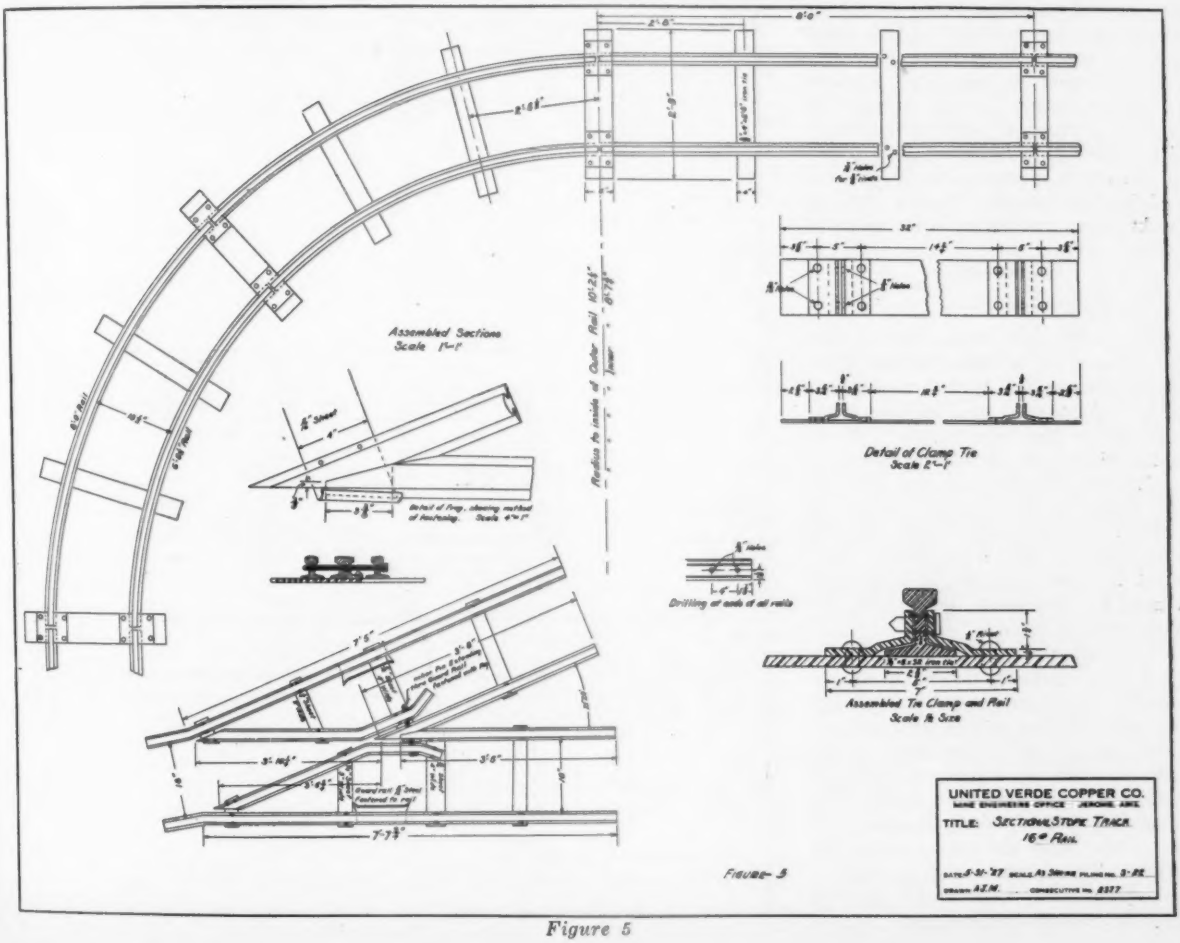


Figure 5

In breast stoping, the powder charge is usually taken as one stick per foot of hole. Nine sticks would, therefore, be the usual charge for a 9-ft. hole. The use of stemming in tests has shown a saving in powder consumption of approximately 20 percent.

Handling Material to Stopes

The size of the stopes and the height above the level determine the method of handling timber and supplies. In large stopes of approximately 100,000 sq. ft. in cross-sectional area, it is usual to install a small cage and air hoist for handling both men and supplies. The average stope is served by an Anaconda-type hoist with small rectangular box 12-in. by 14-in. by 4-ft. in length with open front. Five-eighths-in. plough steel cable and 18-in. sheaves are standard equipment. A portion of the cribbed manway is boarded off to prevent the small skip from hanging up. When a stope is carried to 40 or 50 ft. of the level above, the material is lowered from above. Timbermen handle their own timber into the stopes from the level. When two miners work in a single stope, a chucktender furnishes them with sharp steel and collects drill steel, broken hoses, etc., and delivers them to the level below where they are collected by the nipper and sent out to the station.

Chucktenders in stopes are required to muck a definite number of cars per shift in addition to their other duties. The number of cars varies from 3 cars on full chuck allowance to 10 cars for half-chuck allowance. In this way the chucktender participates in the muckers' bonus.

Development

Drifts and Cross Cuts

Main drifts and cross cuts are carried 6 by 8 ft. in cross section where untimbered and 5 ft. by 7 ft. in the clear where timbered, excepting in main gangways where they are carried 5 ft. by 10 ft. Figure 6 shows standard timber framing for gangway sets. Oregon pine timber is used except where the conditions are conducive to decay, and although cedar has been used to some extent in these locations, it is planned to treat all permanent timber with Aczol or Wolman salts.

The number of holes and type of round varies greatly, depending on the character and hardness of the ground. The most common rounds used are the V cut, toe cut, and upper cut. In any of these rounds the number of holes will vary from 9 to 10 as high as 28. The V cut will pull a greater footage with less powder than the toe or upper cut rounds. The pyramid cut is used to some extent, but it is easier for the miner to connect the cut hole in a V cut than it is in a pyramid cut. Until recently all drifting was carried on bonus, the base rate varying from 0.3 ft. per machine shift in hard iron with a drilling speed of 3 in. per minute and 24 holes per round, to 3.4 ft. per machine shift for soft ground with a drilling speed of 15 in. or more and requiring 10 holes to break the ground.

The contract system has gradually replaced the bonus system on practically all development work, the contract including mining, mucking and explosives. The contractor is not only guaranteed a minimum of day's pay, but is given any benefit of what he would have made were the drift on a bonus rating.

The average cost of drifting for the year 1926 was as follows:

	Cost Per Foot
Labor	$7.87
Explosives	2.44
Timber	.41
Compressed air	.55
Repairs	1.44
Supplies	.38
Total	$13.08

Mucking

In contract drifts, the mucking is a part of the contract. Where a drift is carried on bonus, the standard is based on 7.2 cars (18 cu. ft.) of iron or 8 cars of schist per man shift for a 150-ft. tram. For trams in excess of 150 ft. a certain allowance is made depending on local conditions.

All mucking is performed by hand and hand-trammed to where the cars can be picked up by a motor. Mucking ma-

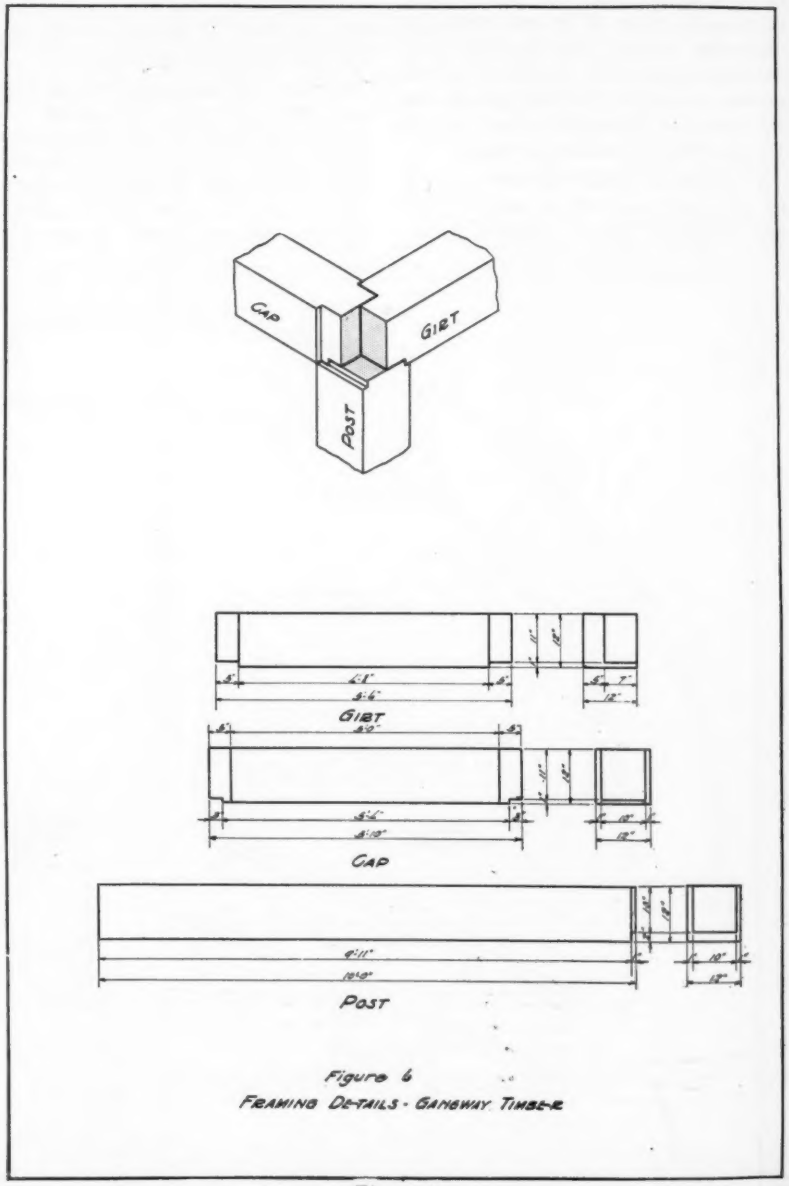


Figure 6
FRAMING DETAILS - GANGWAY TIMBER

Figure 6

chines and scrapers with inclined loading docks have been tried out at various times, but have not proven flexible enough on ordinary development work.

Raises

Raises are, with a few exceptions, standard as to size, being approximately 6-ft. by 10-ft. cross section. All raises over 50 ft. in height are timbered with 5-ft. by 8-in. by 5-ft. cribbing. Where a permanent manway is necessary, double cribbing, 5 ft. by 8 in. by 10 ft., is used. The standard type of round consists of from 12 to 28 holes, one or two rows of holes being drilled on the chute side and 3 to 5 rows on the manway slide. The number of holes and amount of powder necessary to break the round depends on character and hardness of the ground and is largely left to the miner or contractor.

Material is handled from the sill to the face by either a column-type little tugger or an Anaconda hoist, used with a 12-in. by 14-in. by 4-ft. steel bucket.

The bonus standards for raises vary from 1 ft. per shift for chute raises with a drilling speed of 1-in. per minute to 3.33 ft. in ground with a drilling speed of 18 in. per minute. Bonus rates on cribbed raises vary from 0.25 ft. per shift to 0.83 for ground with a drilling speed varying from 1 in. to 18 in. per minute.

The average cost of raising during the year 1926 was as follows:

	Cost Per Foot
Labor	$11.93
Explosives	3.01
Timber	4.07
Compressed air	0.93
Repairs	2.55
Supplies	0.42
Total	$22.91

Tracks

Forty-pound rail at 18-in. gauge and 6-in. by 6-in. by 30-in. ties, spaced at 18-in. centers, is standard for all motor haulage drifts. A small footage of 16-pound track is used on the upper levels where the tramming is performed by hand, and in sublevel work and in top slice stopes. No. 4 and No. 5 manganese steel frogs are standard and are rebuilt by electric welding when worn. Switch points are made up out of 40-pound rail in the local shops; also a switch throw of simple design, together with the necessary rail clamps, spacers, etc. A minimum radius of 50 ft. is maintained in all underground trackage.

Locomotives and Cars

Trolley-type locomotives are used on main haulage levels, and storage battery motors for intermediate levels. The 250-volt, D. C., current for motor haulage is carried by No. 0 wire, excepting in Hopewell tunnel where No. 000 is used. In open drifts the wire is suspended on 4-in. by 4-in. by 18-in. wooden blocks, fastened to the back by ⅝-in. expansion bolts. Wherever the trolley is lower than 8 ft. it is boxed with 1¼-in. by 8-in. boards. In timbered gangways, a hinged board covers the bottom of the trough in front of chutes to prevent the chute puller from coming in contact with the trolley. The rails are bonded with 8-in., No. 40, welded-type rail bonds.

Figure 7—Koppel 30 Cu. Ft. Rocker Bottom Dump Car

Six-ton Jeffrey locomotives, equipped with solid slab frames are standard for trolley haulage. The motive power is derived from two 18-h. p. motors connected to the drive wheels by intermediate gearing. The drawbar pull is 3,000 pounds at a speed of 6 miles per hour on level track. The length of a train usually limits the number of cars rather than the capacity of the locomotive. A 16-car train of massive sulphide ore gives a trailing load of 50 tons.

Four 3½-ton and eight 5-ton storage battery locomotives are also used for tramming purposes. The 3½-ton locomotives are equipped with two 6 h. p. motors with 88 A-4 Edison cells having a capacity of 13.9 k. w. hours or 150 ampere hours. The 5-ton locomotives have two 10 h. p. motors with 104 A-4 cells with a rating of 150 ampere hours or 100 A-6 cells with a rating of 225 ampere hours.

The battery boxes are equipped with rollers on the bottom so that the whole battery unit may be easily replaced with a fully charged set at any time. Each charging station is equipped with a steel platform the same height as the motor frame and the battery boxes are rolled on and off by hand. The charging sets are of the constant potential type and operate from the trolley circuit.

Formerly, every second level was a main haulage level and equipped with trolley haulage, the intermediate levels being served by storage battery locomotives. It was found cheaper to haul direct to the ore hoisting shaft on each level than to pass the ore down to the trolley equipped levels, and at present the 5-ton storage battery locomotives are doing the same work as the trolley-type locomotives in tramming the ore an average distance of 800 ft. from the stopes to No. 5 ore shaft. It is very probable that all new levels will be equipped with storage battery locomotives. A six months' test on the two types of haulage showed a cost of 36 cents per ton mile for the storage battery locomotives as against 53 cents for the trolley type. These costs included labor, maintenance and power only.

Two types of cars have been standardized as for mine haulage. An 18-cu. ft. car, equipped with Sanford Day roller-bearing wheels is used for hand tramming. The car weighs 960 pounds and is easily handled and dumped by one man. On motor haulage levels, a Koppel, rocker-bottom car with a capacity of 30 cu. ft. and weighing 2,500 pounds is used almost exclusively. Fig. 7 shows a general view of the car. It is equipped with 12-in. roller-bearing wheels at 18-in. gauge. A particular feature of this car is the double trunion, which gives a minimum overhang in the dumping position and permits dumping in standard width gangways when handling waste for fill. This car is dumped by means of a piece of drill steel, one end of which is inserted in a shallow hole in the wall of the drift, the other end being placed against a lug on the side of the car. As the car moves forward, the drill steel forces the car over. Several mechanical devices have been tried out, but the drill method is simple and as effective as any scheme tried.

The average cost of ore tramming for the year 1926 is as follows:

	Per Ton
Motor haulage	$ 090
Hand tramming	.008
Electric power	.008
Supplies	.003
Repairs	.022
Total	$.131

Hopewell Tunnel Transportation

All ores from the open pit and underground operations, also excess waste from the shovel pit, are transported from the main loading bins on the 1,000-ft. level through Hopewell Tunnel to the transfer bins at the portal of the tunnel. These bins have a capacity of 10,000 tons. Because of the character of the heavy sulphide, particularly the fine calcined material from the fire zone, it is necessary to have chute openings as large as possible to prevent the fines from building up in the bins. Fig. 8 shows a general view of the chute spacing and rugged mechanical linkage for opening the gates.

The tunnel is 7,000 ft. in length and is 10 by 13 ft. in the untimbered portions. A total of 2,700 ft. is timbered

with 10 by 10-in. Oregon pine sets at 5 ft. 6 in. centers. The sets are 9 ft. high with a 10-ft. cap and posts battered to give a width of 12 ft. at the sill.

The ore is handled in 40-ton bottom-dump Koppel standard-gauge cars provided with compressed air cylinders for operating the dumping mechanism. Baldwin-Westinghouse trolley locomotives equipped with two 75 h. p. commutating pole-type motors and automatic air brakes handle an 8-car train at a speed of 7 miles per hour. The average gross weight of the train handled by each locomotive is 435 tons. Four motor crews of 3 men each are able to transport 5,000 tons of ore per day, a distance of 1½ miles. The bonus standard on transportation of ore through this main haulage tunnel is 5.5 cars per man shift.

The burned sulphide from the shovel pit causes considerable inconvenience in handling because of the finely divided sulphide dust. The loaders are provided with small nose-type rubber respirators with lime-soda containers.

The cost for Hopewell Tunnel transportation during the year 1926 was as follows:

Total tonnage transported: 1,387,397.	
Cost per ton:	
Labor	$0.033
Supplies	.001
Electric power	.008
Compressed air	.005
Repairs	.025
Total per ton	$0.072

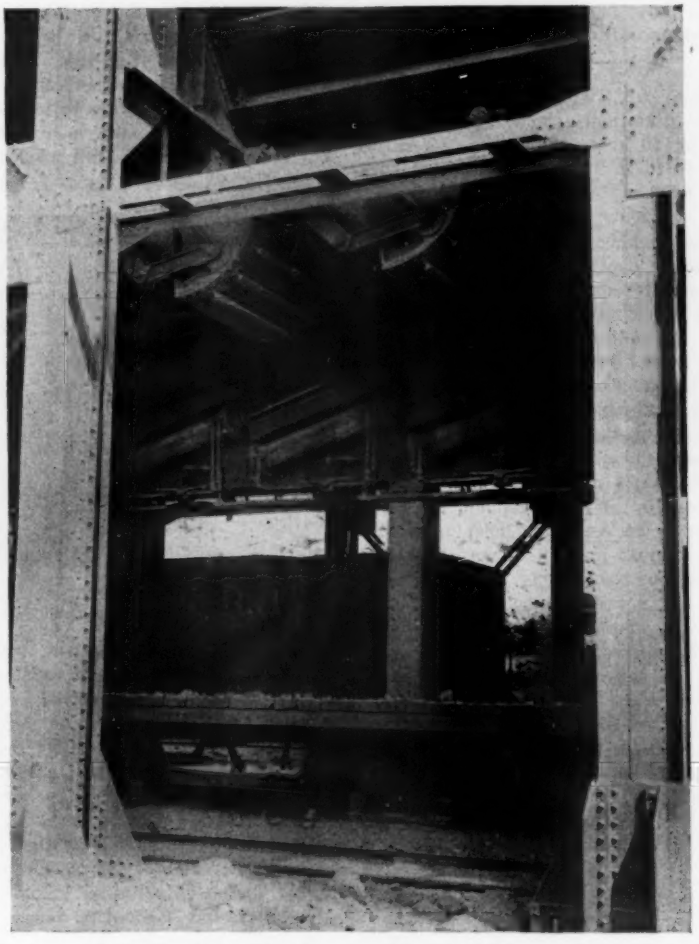


Figure 8—View Showing Ore Bin Chute Construction

Ventilation

The ventilating system and special problems encountered at the United Verde mine were given in detail in a paper presented at the March meeting of the Arizona section of the American Mining Congress and appeared in the March, 1927, issue of The Mining Congress Journal.

The primary air will be supplied by a 4 ft. 6 in. by 9 ft. Jeffrey double inlet fan which will deliver 250,000 cu. ft. of air against a total resistance of 5.3-in. water gauge at 280 r. p. m. The fan will be driven by a 400 h. p., 280 r. p. m., 2,200 volt, 3-phase G. E. slip ring motor during a daily normal operation of 14 hours. An auxiliary belt drive will act as a spare and will also be used during graveyard shift to deliver 160,000 cu. ft. of air per minute. A system of jaw clutches will permit changing from one drive to the other with little or no delay. This speed variation was selected in preference to a gear shift unit.

No. 250 Coppus Vano blowers and Sirocco No. 3 blowers direct connected to 5 h. p., 860 r. p. m., d. c., squirrel-cage motors are used for auxiliary ventilation with 11-in. galvanized tubing up to 500 ft. in length. For headings over 500 ft. in length, 16-in. tubing is used with a No. 4 Sirocco fan. For headings over 1,000 feet, a Sturtevant No. 10 Monogram fan is used. This unit will develop a total pressure of 8.5 in. water gauge at 860 r. p. m. Fifty-foot lengths of Ventube are used to deliver the air from the ends of the tubing to the face.

The galvanized pipe is made in the mine shops at a cost of $1.10 per foot for the 16-in. 14-gauge pipe, and $0.55 per foot for the 11-in., 16-gauge pipe.

A separate inlet for the fresh air and a separate outlet for the vitiated air together with a system of splits has been found necessary for adequate ventilation to the 3,000 level. The air raise described in detail in the above mentioned paper on ventilation has been completed for the 1,000 level fan inlet to the surface and the adits on the 500 level and the main haulage tunnel on the 1,000-ft. level are now naturally incast, and this natural ventilation has greatly increased the volume of air into the mine and improved the ventilation materially on the upper levels where rock temperatures are as high as 150 degrees C.

Compressed Air

Compressed air is furnished by three electrically driven Ingersoll-Rand Compressors, all of which are the two stage cross-compound type, delivering air at 100 lbs. No. 1 is of the P. B-2 class, 18¼-in. by 30¼-in. by 24-in. stroke with a displacement of 1,500 cu. ft. per minute. It is belt driven by a 300-h. p. General Electric induction motor operating on a 60-cycle, 2,200-volt alternating current.

No. 2 Compressor is a 19¼-in by 31½-in. by 30-in. stroke Ingersoll-Rand with a displacement of 3,000 cu. ft. of air per minute. It is driven by a G. E. 600-h. p. motor through a short center belt drive.

No. 3 Compressor is an Ingersoll-Rand type P. R. E.-2 28-in. by 46-in. by

36-in. stroke with a displacement of 6,800 cu. ft. of free air. It is direct connected to a 1,163-h. p. General Electric synchronous motor. The exciter is a Westinghouse type C. S., 38.5 h. p., 2,200 volt, 60 cycle motor, direct connected to a Westinghouse 25-k. w., 125-volt, 200-ampere, shunt-wound generator.

The air is delivered to the collar of No. 6 shaft through 2,000 ft. of 16-in. standard wrought iron pipe. The air column in the shaft is 12 in. and 5-in. laterals on the levels are carried to the ore body. From here it is reduced to 3 in. or 2 in., depending on the length which it is extended along the ore body. Two-inch risers are carried up the manways to the stopes, where they are reduced to two 1-in. headers for connection to 1-in. air hose.

The average monthly power consumption for compressed air is 480,000 k. w. hours per month, and approximately 7,500,000 cu. ft. of free air is compressed daily at a cost of $340. The air is used approximately as follows:

	Percent
Machine drilling	30
Hoisting pumps, misc.	20
Ventilation and Leakage	50
Total	100

Power Distribution

Electric power is generated at the Clarkdale smelter, utilizing waste heat from the reverberatory furnaces. In the event of shortage from this source, the Arizona Power Company with plants at Tapco, Childs and Irving furnish the balance. In addition, a battery of oil-fired boilers is available.

Power is received at the 500 substation at 45,000 volts and there stepped down to 2,300 volts for transmission underground. 110 volts is used throughout the surface shops for small electric equipment excepting crane motors which run off of the trolley circuit at 250 volts, d. c.

A small substation 20 by 32 ft. by 13 ft. in height is located adjacent to No. 6 hoist room on the 500 level, approximately 1,700 ft. from the portal of the tunnel.

The power used underground is carried from the powerhouse to this substation by three 500,000 cir. mil. lead insulated, armored submarine type cables, one 3 conductor 600,000 cir. mil. cable, and one 3 conductor No. 3-O cable. All cables used underground are of submarine-type construction.

Two motor generator sets of 500 k w. capacity furnish 250-volt direct current for trolley locomotives, charging panels for storage battery locomotives and small fans used in auxiliary ventilation. At this substation is also located a switchboard so that in the event of trouble in the incoming lines through the 500 adit, power can be fed through an auxiliary line maintained through the 1,000-ft. haulage tunnel. Approximately 31 locomotives are in service, ranging in size from 3-ton storage battery locomotives to 25-ton trolley locomotives used in Hopewell Tunnel.

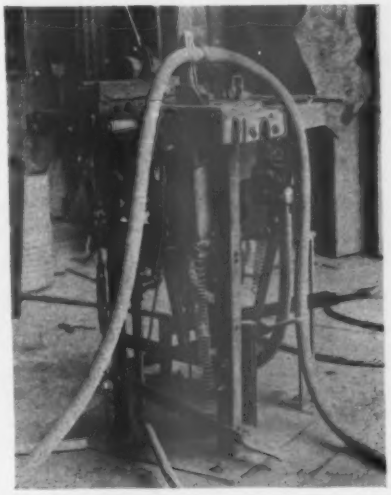


Figure 9—McKee Hose Facilitator

All power cables are carried down No. 6 shaft to a distributing station on the 1,000-ft. level. One 3 conductor 500,000 cir. mil. cable takes care of No. 5 hoist and the main fan. Two 3 conductor No. 2-O cables handle the pumps and miscellaneous hoists and motors used underground. The lighting circuit is a 3 conductor, size 1-O; the trolley circuit two 1,000,000 cir. mil. cables, and the signal system a No. Six 44-wire cable. These are carried in the open and suspended at intervals of 150 ft. by metal clamps.

All shaft stations, main drifts and timbered gangways are lighted by electricity. 25-watt lamps are spaced at 100-ft. intervals in the main headings, and 30 to 50 ft. in timbered gangways. Red lights are located at powder magazines and green lights at safety chambers.

A magneto type mine phone, Western Electric type 1336 E, is located on each level; at No. 6 station and in all hoist rooms. They are connected on 5-party lines to the local exchange of the Mountain State Telephone & Telegraph Company.

The pull bell system is used in shafts for signalling the hoist operator. Each station is provided with a push button which operates an annunciator on the engineer's platform indicating the level from which the call came. A return flash is given by a return signal lamp above each call button, all lamps being connected in parallel. The annunciator system is used on both the call buttons and cage signals as a matter of safety.

The mine power consumption averages 1,000,000 k. w. per month and costs $0.01475 per k. w. hr. The distribution in percent of total and k. w. hrs. per ton of ore is as follows:

	Percent of Total	K. W. Hrs. Per Ton of Ore to Smelter
Compressed air	51	4.3
Hoisting	10	0.8
Pumping	2	0.2
Shovel operations	5	0.4
Ventilation	15	1.3
Haulage	9	0.8
Lighting	6	0.5
Shops and Misc.	2	0.2
Total	100	8.5

Hose and Fittings

Three sizes of hose are used throughout the mine, viz, ½ in. for water, ¾ in. for pluggers and stopers, and 1 in. for all mounted drills. All hoses are provided with a standard lug coupling and spud which fits all types of machines. (Details of these fittings were given in the Engineering and Mining Journal, June 26, 1926.) This standard hose fitting has a decided advantage in that it allows any size hose to be used on any drill without changing connections.

All damaged hose is brought to the surface and the necessary repairs are greatly facilitated by the "McKee Hose Facilitator" (Fig. 9). This device tests, cuts hose, inserts nipples and wraps hose with wire, all by use of compressed air. A mechanical device is also used for forming the wire loops from ordinary galvanized telephone wire, which effects an appreciable saving over the welded wire loops.

Nipples for connecting two hose ends are made from scrap pipe, tapered on the ends and recessed in the center. All spuds and nipples are doped with rubber cement before inserting in the hose. Each hose is numbered by stamping on the inside of the hose coupling and an accurate record of date of repairs and life of each hose is kept. This gives exact data on the service of any particular brand of hose.

Pumping and Drainage

The United Verde Mine is comparatively dry, the volume of water pumped averaging but 180,000 gallons per day.

The surface water from that portion of the mine above the 1,000-ft. level is delivered by gravity from level to level through two 13/16-in. diamond drill holes to the 1,000 level where it is collected and delivered to the precipitating flumes at the portal of Hopewell Tunnel through 7,000 ft. of 10-in. redwood pipe line.

Mine water below the 1,000 level is handled by two electrically driven Aldrich 6½-in. by 12-in. quintuplex pumps. These pumps are rated at 500 gals. per

minute against a 1,000-ft. head. Double acting plunger type air pumps are used for auxiliaries. The pump column is a lead lined 8-ft. standard wrought iron pipe with extra heavy cast iron flanges. It is supported in the shaft by bolted clamps made out of 1-in. by 4-in. strap iron and placed at 15-ft. intervals.

The total cost for pumping and drainage during the year 1926 was $37,341.94, which represents a per ton cost of $0.049 per ton of ore.

Precipitation and Leaching

Surface waters in passing down through the hot upper levels of the mine become high in copper content, averaging 20 grains to the gallon. The water is passed from level to level through two 13/16-in. diamond drill holes, and is collected on the 1,000-ft. level and carried to the precipitating flume at the portal of Hopewell Tunnel through 7,000 ft. of 10-in. redwood pipe line. The flow will vary widely during different seasons, but will average 25 gallons per minute. The water is passed over 1,800 ft. of flumes filled with scrap iron and the overflow conveyed to the leaching dump.

Flumes are constructed with 3-in. cedar or redwood, 4 planks wide with 2-in. by 12-in. sides, and angle braces outside to hold the sides in place. Both tongue and groove and plain edges corked with oakum have been used. Copper nails are used throughout and as few exposed to the copper water as possible.

Boxes 4 by 6 by 4 ft. deep are placed at intervals of 400 ft. for collecting the precipitate. Cans collected from the city dump are used in the last 400 ft. of the flumes and scrap iron in the rest of the flumes.

During the year 1926, 222 tons of precipitate averaging 80.6 percent copper was made at a cost of $26.69 per ton, $22.22 of this amount representing labor cost.

Leaching

In 1921 some experimental work was done on low grade massive iron ore, and although results at the time were negative, constant exposure of this dump to the weather has proven the possibility of leaching low grade massive sulphides.

All low grade sulphide and schist ores from the pit containing 1.5 percent copper or less are transferred through the main Hopewell haulage tunnel and placed on a leaching dump below the mine water precipitating flumes. This dump contains 84,000 tons at this date.

The overflow from the precipitating flume and about 50 gallons of mine water per minute are distributed over the surface of the dump and the run-off carried over 2,000 ft. of flumes similar to those described above. The average daily precipitate recovered from this portion of the precipitating flume is 1.5 tons. Very little technical supervision is given to this plant and no data is kept as to water analysis or volume used throughout the year. A bright tin can is placed in the overflow as a check on recovery, and the volume of water controlled to give an approximate recovery of 92 percent. The overflow is checked occasionally by water analysis and has proven the practicability of the tin can as an indicator of the amount of copper loss.

Drilling Practice

Diamond Drilling

Long diamond drill holes are used to explore the different geological formations, while shorter holes are used to develop and block out the massive sulphide ores.

During 1926, 21,153 ft. of diamond drilling was performed. Forty-three percent of the holes were under 300 ft. in length, 39 percent between 300 and 600 ft., and 18 percent of the holes were between 800 and 1,200 ft. in length. Core recovery averages 85 percent. There are three drill crews, consisting of a runner at $5.76 per shift and helper at $4.80. Drill equipment consists of three Sullivan type-C machines and two Longyear U. G. machines. The ES bit, which gives a core of 7/8-in. is used on holes up to 1,000 ft. All drilling is on bonus, the base rate being $1.27 per ft. for holes up to 100 ft. in schist which is rated as unity. The average cost per foot for 1926 is as follows:

	Per Foot
Labor	$1.28
Carbons	.45
Supplies	.18
Power	.05
Repairs	.09
Cutting stations	.12
Total	$2.17

Sectional Steel Drilling

Sectional steel drills are used to prospect stope walls and for short holes in development work to locate contacts where driving contact drifts. The Waugh Turbo 34 is used with a special water connection. Sectional steel is forged from 1¼-in. hollow-round drill steel. The sleeves are purchased at a cost of $6.34 each.

During 1926, a total footage of 9,412 feet was drilled at an average cost of $1.066 per foot. The average footage per shift was 15.5. The detailed cost per foot is given below:

	Per Foot
Labor	$0.693
Repairs	.034
Threading dies	.002
Oil	.004
Compressed air	.088
Steel sharpening	.146
Broken steel	.045
Sleeves	.054
Total	$1.066

Although sectional steel holes have been drilled to a depth of 150 ft., the average is about 60 ft. The most efficient depth as far as costs are concerned is from 25 to 60 ft.

Rock Drills

The following types of rock drills are used at the United Verde mine:

Ingersoll-Rand 248 for drifting and stoping in schist and medium sulphide.

Chicago Pneumatic C. P. 6 and Denver Rock Drill No. 7 for drifting and stoping in hard ground.

Waugh Turbo 34 for sectional steel drilling.

The hand-rotated Ingersoll-Rand CCW-11 for driving raises in medium ground and the Waugh 39 in hard iron.

The Sullivan DP 33 jackhammer is used for plugging boulders. It is also used for toe holes in the open pit.

The Waugh 37 is used in shaft work.

The inventory of machines is as follows:

Leyners	110
Stopers	160
Jackhammers	170

The average cost per drill shift for repairs and replacements is as follows:

Leyners	$0.75
Stopers	1.10
Pluggers	0.60

The average number of machine shifts per day is 110, and the average number of machine shifts per 1,000 tons is 42 for the underground ore.

The drilling speed in various classes of ground is as follows:

Ground Classification	Approximate Drilling Speed Inches Per Min.
Very good	18
Good	12
Medium	8
Hard	4

Minor repairs to drills are made underground by the powder man who also

has charge of the tool house on each level. If the machine requires taking apart, it is sent to the drill repair shop on the surface, where it is repaired, tested and sent back to the same level from which it was sent up. Each machine is stamped with a serial number and a detailed account is kept of the date and repairs on each machine so that it is possible to tell the exact cost of repairing any particular drill.

Water tubes are made up in the drill repair shop by means of two dies of simple design and operated by a small pneumatic gun. The tubing is heated in a small forge for drawing down the ends, whereas the buttons are formed cold.

Practically all drills are equipped with the Waugh L O-3 line oiler.

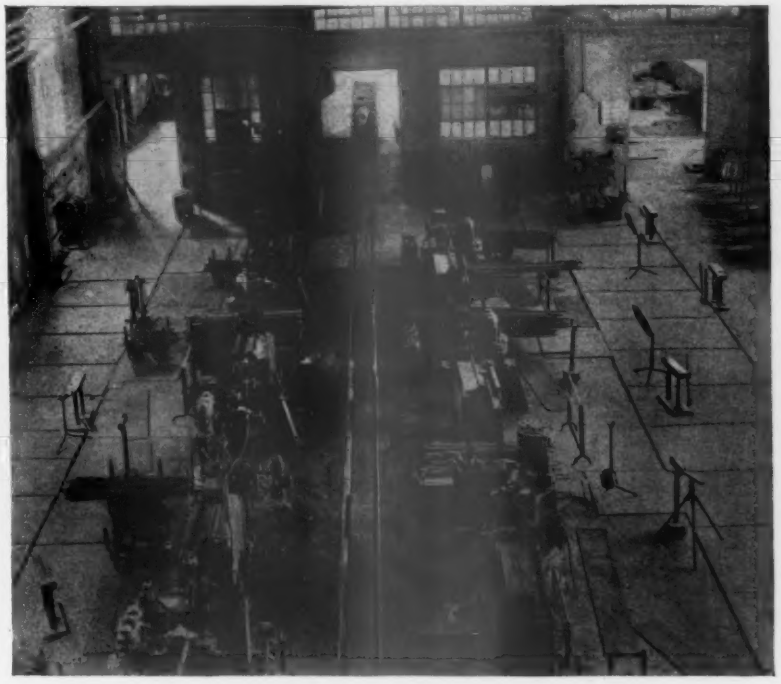


Figure 10—Interior View of Drill Sharpening Shop

Rock drill testing is under the supervision of W. P. Goss, efficiency engineer, who also has supervision over the drill repair and steel sharpening shops.

Drill Steel

Two sizes of drill steel are used; viz, ⅞-in. quarter-octagon for jackhammers and stopers, and 1¼-in. hollow-round for all Leyner-type machines. The double taper cross bit with 1/16-in. gauge reductions is standard practice. The following tabulation gives the various lengths of steel used:

Machine	Starters Gau. Ins.	Lgh. Ft.	No. of Chgs.	Finishers Gau. Ins.	Lgh. Ft.
Pluggers	1⅜	2½	..	...	.....
Underground jackhammers and stopers	1⅞	2½	10	1¼	10′-10″
Open pit jackhammers	2¼	2½	12	1⅛	20′-0″
Underground leyners.	1⅞	2½	10	1¼	10′-10″

Approximately 140 tons of steel are used per year, or 0.215 pounds of drill steel per ton of ore mined. About 28,000 pieces of steel are kept in circulation at one time. Drill steel is selected according to gauge wear, depth of penetration and drilling speed as determined by actual tests. Steel with a carbon content of .80 to .85 percent is the only kind considered. At present, we are using Ingersoll-Rand Sandviken steel.

Drill Shop Practice*

The drill steel from the mine is brought out to the drill sharpening shop on standard steel cars on afternoon shift and distributed in racks according to lengths, each sharpener handling but two or three lengths of the same size steel. During the day, these same nippers fill their orders for the mine from revolving racks or excess storage racks outside the building, and this steel is then delivered underground on graveyard shift. No transfer of steel is necessary, the steel trucks going directly to the working level.

The drill steel is heated in an oil-fired furnace built in the mine shops and equipped with Gilbert and Barker 1½-in. single jet burners. Oil consumption is 3 gallons per hour of 24° Baume semi-Diesel oil. The air is furnished at 1.25 pounds pressure by a General Electric, high-speed, centrifugal blower.

The bits are forged at 1,900° F. in Ingersoll-Rand sharpeners and tempered by Gilman CE-21 heat treating machines. Bits are quenched at 1,400° F. and range in hardness from 550 to 600 in Brinnell Scale. Shanks are forged in No. 8 Waugh Sharpener at a temperature of 2,100° F. and hand tempered at 1,600° F. in Houghton No. 2 quenching oil. The hardness of shank is maintained at 375 to 400, Brinnell hardness.

All furnaces are equipped with thermo couples and indicating pyrometers. The Gilman tempering machines are equipped with two thermo couples and two indicating and one recording pyrometer. This equipment is checked daily by a precision poteniometer with platinum thermo couple heated by an electric muffle furnace. The pyrometer equipment was furnished by the Brown Instrument Company of Philadelphia, Pa.

An Improved America Model Brinnell Hardness Tester is used for testing hardness of bit, shanks and dollies, and forging blocks which are also made in the mine shops at an appreciable saving.

The capacity of the shop (Fig. 10) is 2,500 pieces of steel per 8-hour shift. Approximately 1,800 to 2,000 pieces of steel are handled daily by a shop force of 24 men. The bonus rate was formerly based on a rate of 70 pieces of steel per man shift, but at present is on a mine machine basis, or the shop is allowed $1.15 per underground machine shift for labor costs. The breakage will average 2 percent on 1¼-in. hollow-round steel and 8 percent on ⅞-in. quarter-octagon.

The cost of sharpening steel is as follows:

	Per piece of steel	Per ton ore mined
Nipping	$.009	$.004
Labor (sharpening and hardening)	.063	.031
Oil	.006	.003
Air	.017	.008
Repairs	.040	.020
Miscellaneous	.005	.002
Total	$.140	$.068

* More detail may be secured from "United Verde's Drill Shop Practice," by W. P. Goss, E. & M. J., Vol. 123, January, 1927, and "Heat Treating Rock Drill Steel," by the same writer, The Mining Congress Journal, March, 1927.

Hoisting Practice

No. 6 Shaft

No. 6 shaft is used entirely for service and extends from the 400-level to the 2,400-level. Fig. 11 shows a section of this shaft. Above the 1,950-level it is concreted solid, and below it is concreted in 2½-ft. rings at 5-ft. intervals. This method of concreting reduced the cost per foot of shaft from $87.79 per ft. to $50.11, and the construction methods and details were presented in the April, 1927, issue of The Mining Congress Journal by W. J. Flood. Fig. 12 shows the type of gates used on all shaft stations.

The cage compartment is 8 ft. by 13 ft., the pipe and manway compartment is 4 ft. by 9 ft. 4 in., and the counterbalance compartment is 4 ft. by 3 ft. A sublevel at the collar of the shaft permits loading and unloading of both decks at one time when handling the shift. Each deck holds 50 to 60 men, and it requires 43 minutes to lower a shift of 360 men. Approximately 80 trips are made daily, handling 1,800 to 1,900 men, 150 to 175 truck loads of supplies, besides miscellaneous material. The running time is distributed as follows:

	Percent
Handling men at regular shift periods.....	17
Handling supplies	25
Miscellaneous trips	15
Idle and delays	43

The hoist room is located on the 500-level. It is 44 ft. by 45 ft. in section and 26 ft. in height, and is of reinforced concrete construction.

The hoist is of Nordberg manufacture with a 12 ft. by 6 ft. smooth face drum holding 2,500 ft. of 1¾-in. cable in two layers. The rope speed is 800 ft. per minute with an acceleration of 6 seconds and retardation of 5 seconds. A reel for ½ in. by 5½ in. flat rope for the counterweight is rigidly coupled to the main drum. The brakes are of the parallel motion, gravity post type, set by a deadweight and released by a hydraulic oil cylinder. In addition to the main brake, an auxiliary brake has been placed on the motor drive shaft pinion as an added safety measure.

The hoist is driven through a flexible coupling by a 350 h. p. slip ring induction motor at a normal speed of 350 r. p. m.

The cage is of double deck design, 6 ft. 9 in. by 12 ft. 7 in. in section, and will accommodate 60 men to the deck or four standard timber or service trucks. The cage is provided with inward swinging gates with offset hinges to prevent the gates from swinging outward. Besides the usual safety dogs on the cage, the hoist is provided with an overspeed safety device which throws off the power and applies the brakes in the event that the cage should attain a speed of over 1,000 feet per minute. The shaft is also provided with the usual limit switches at both upper and lower extremities.

Cable Practice

The hoisting rope used is a Roebling 1¾ in., 6 by 19 Blue Center steel, Langley, modified seal construction. The total load on the cable is 21 tons. The cable is inspected once a week and broken wires counted by means of a two-piece steel ring that fits over the cable and is held by the inspector. Sockets and cable attachments are inspected daily. The cable is resocketed at intervals of six months, and cut back on the

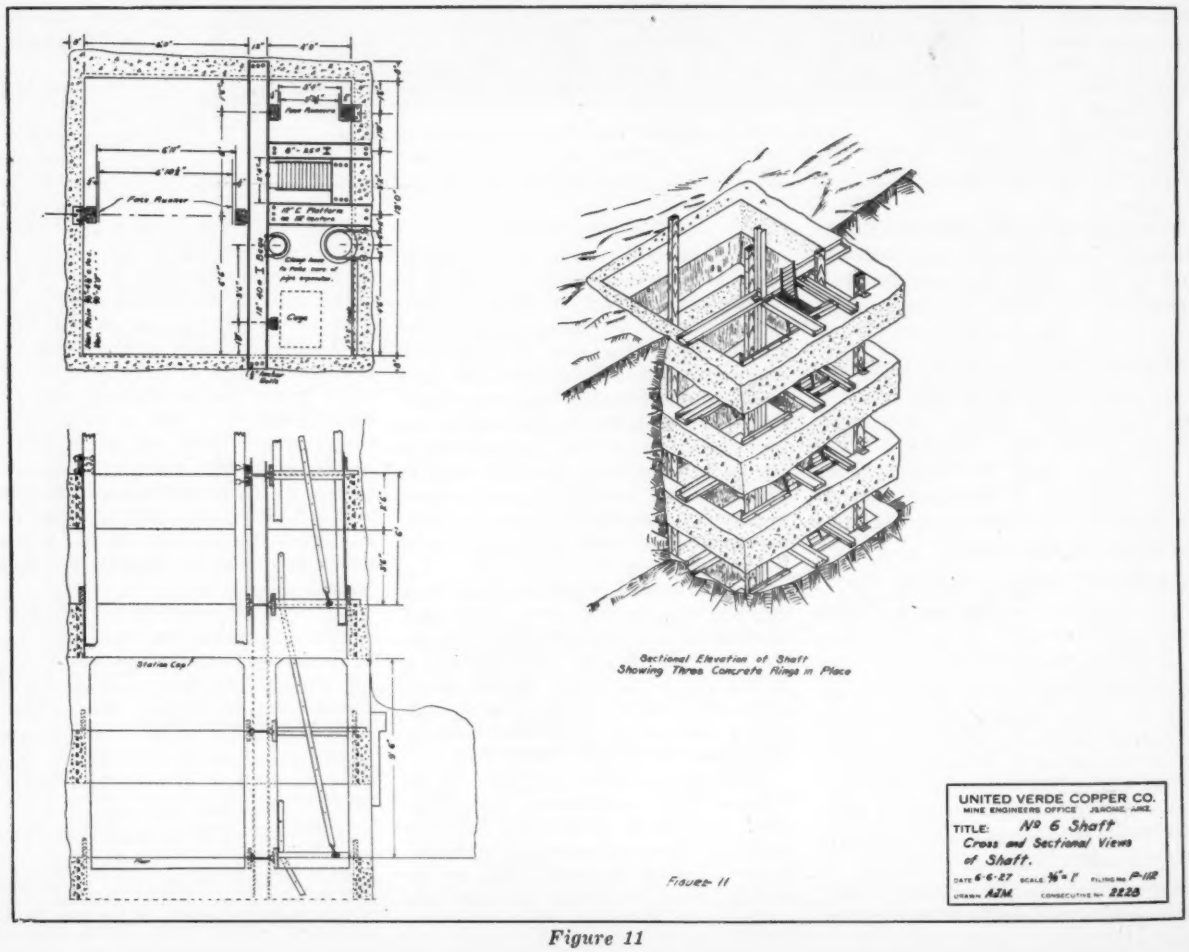


Figure 11

drum end once a year. The twist in a new cable is relieved twice during the first three months' operation and after then only when the cable is resocketed. Vesuvius cable dressing, applied at intervals of four to five weeks, gives satisfactory penetration and keeps the cable well lubricated. Although the recommendation as given in Bulletin 75, Rules and Regulations for Metal Mines, is adhered to in so far as the allowable number of broken wires is concerned, the cable in question is replaced every two years regardless of the number of wires broken.

The flat cable is a 1½ in. by 5½ in. 12-strand 4 by 7 plow steel with single lacing. The average life of this rope is 7 months. The total load, including the weight of the cable, is 17 tons.

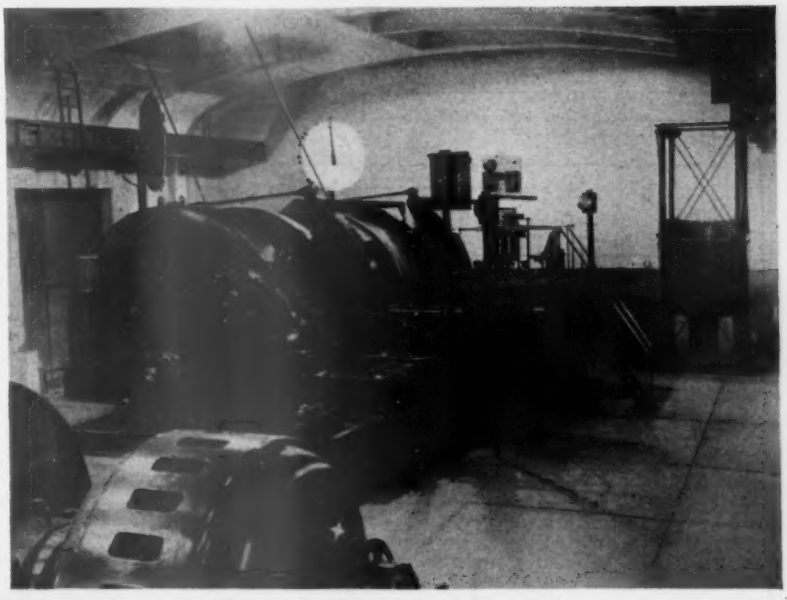


Figure 16—No. 5 Underground Hoist

No. 5 Shaft

No. 5 shaft is an ore hoisting shaft and extends from the 800-level to the 3,150-level. It is of concrete construction and contains two hoisting compartments and one manway, all three being 5 ft. by 5 ft. in the clear. The curtain walls are 10 in. thick and are reinforced with ¾-in. bars.

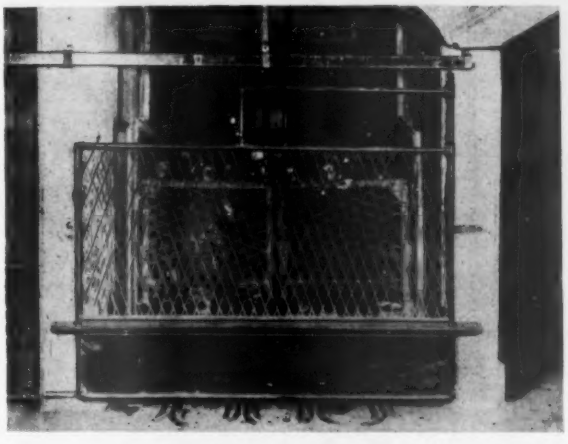


Figure 12—No. 6 Shaft Station showing gate construction

Loading pockets (Fig. 13) are of 500 tons capacity and arranged according to general practice in the mines of the Southwest. The upper gate is of the undercut plate type, while the cartridge gate is of the undercut arc type with movable baffle front. Both gates are operated by compressed air. Fig. 14 shows a spray used to eliminate dust at the loading pockets and is very satisfactory. Small hand-operated pockets are also located below each level for handling waste during development periods.

Guide Practice

The lower part of the shaft is provided with 8-in., 21½-pound, ship-channel guides. Fig. 15 gives the details of these guides and the guide bolt sockets used in No. 5 shaft. In the upper portion of the shaft where the wear from spill is not great, wooden guides are used. Old guides have been successfully repaired by fastening wedge shaped oak strips to the worn edge of the guides by flat headed wood screws. Because of the twist on the cable, the wear is on one side of the guide only. Recent practice is to make the wooden guides out of 3⅝ in. by 7 in. clear, kiln-dried Oregon pine, to which is fastened a 1 in. by 3⅝ in. clear white oak wearing strip.

Spill

Spill on hoisting 2,000 tons a day will average 6 tons. This amount of heavy sulphide cuts the shaft walls, and it has been necessary to build up the curtain walls and shaft walls by means of gunite.

A heavy hinged bulkhead or deflector has been constructed in the hoisting compartments to deflect the greater portion of this spill to the ore pockets. This deflector is electrically operated by remote control from the engineer's platform, and a set of pilot lights indicates its position. The portion of the spill which reaches the bottom of the shaft is drawn through chutes into an 18 cubic foot mine car and hoisted through the manway compartment to the next level above.

Hoisting

No. 5 hoist station is located on the 1,000-level. It is 47 ft. by 81 ft. in section by 22 ft. in height, and is lined with reinforced concrete. The cableway extends at an angle of 60 degrees to the head frame on the 800-level. The sheaves are 10 ft. in diameter, are of ½-in. plate-type construction, and equipped with cast steel liners.

The ore hoist (Fig. 16) is an Allis Chalmers, double-drum, single-reduction geared type, driven by a 650 h. p., d. c. motor with current at 500 volts and a normal speed of 300 r. p. m. Power is supplied to the motor by a 695 r. p. m. fly wheel motor generator set consisting of one 700 h. p. wound rotor induction motor, one 600 k. w., 500 volt d. c. generator, and a 10 k. w., 250 volt exciter.

The drums are 10 ft. in diameter with a 5 ft. smooth face and will hold 2,500 feet of 1⅝ in., 6 by 9 hoisting rope in two layers. The maximum hoisting capacity is 260 tons per hour. The rope speed is 890 ft. per minute. Rope practice is similar to that described under "No. 6 Hoist." The total load on the cable is 15 tons, the average life being two years and tonnage hoisted per rope 760,000.

The skips, which operate in balance, are of 112 cubic ft. capacity, equivalent to 8 tons of sulphide ore and 6 tons of schist ore. They are of rugged construction and weigh approximately 14,000 pounds.

The ore is hoisted to the 800-level, where it is dumped through an electrically driven selector to either one of three storage bins, depending upon the class of ore being hoisted. This selector is controlled from the hoistman's platform and colored pilot lights indicate the position of the selector. These main

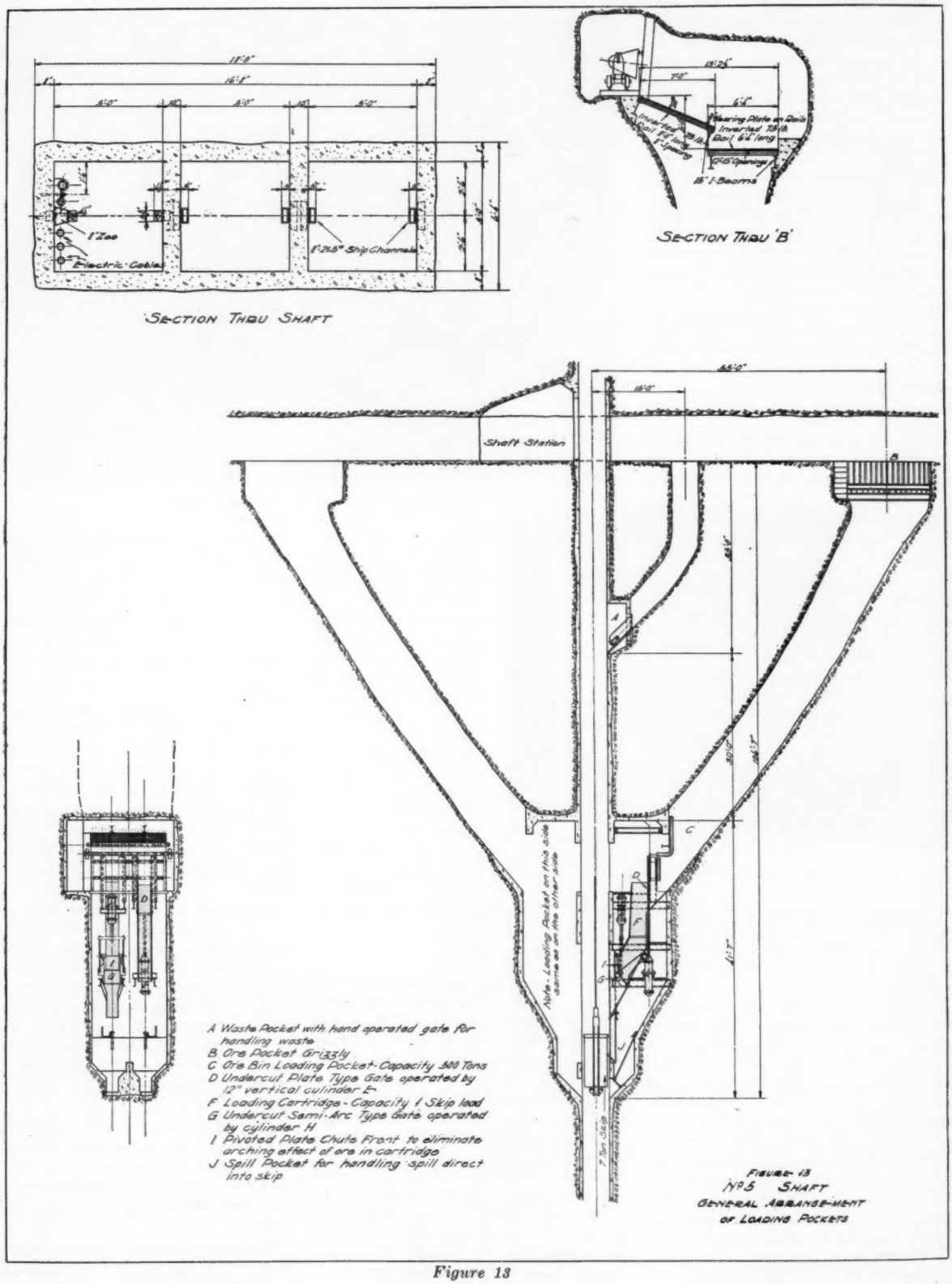


Figure 13

ore bins lead to the 1,000-level and have a capacity of 1,000 tons each. From these bins (Fig. 17) the ore is passed through air-operated verticle-gate chutes to the Hopewell Tunnel cars.

Cost of Hoisting

The total cost of hoisting for the year 1926, including No. 6 service shaft and miscellaneous hoisting equipment throughout the mine, was as follows:

	Per ton hoisted
Labor	$.060
Compressed air	.007
Electric power	.033
Repairs	.054
Total	$.154

The hoisting crew, consisting of hoistman, skip loader and helper, work on bonus at base rate varying from 37 skips per man shift from the 2,400 loading pocket to 96 skips from the 1,200 pocket.

Winze Practice

In order to speed up development on the levels below the 2,400-ft. level while No. 5 hoisting shaft was being constructed, a winze was sunk from the 2,400-ft. level to the 3,000-ft. level.

Sinking operations were carried on in the usual manner and the muck handled by a 16 cu. ft. bucket hoisted on skids and dumped in a pocket on the 2,400 level. The entire length of the winze is timbered with 8 by 8 Oregon pine sets at 6 ft-6 in. centers, the manway compartment being 4 ft. by 5 ft. in section, and the hoisting compartment 5 ft. by 5 ft. The upper 410 ft. of the winze is on an inclination of 57 degrees and the lower 315 ft. on an inclination of 75 degrees.

Upon completion of sinking operations the skids were replaced by 40-lb. rail at 30-in. gauge with pipe and rod spacers every two sets to hold the proper gauge and angle clips every rail length to prevent creeping. A 2-ton skip replaced the bucket for handling muck. Standard mine car wheels were used and a special lug casting bolted to the lower wheel to carry it into the dump. The front of the skip was hinged to open inward to

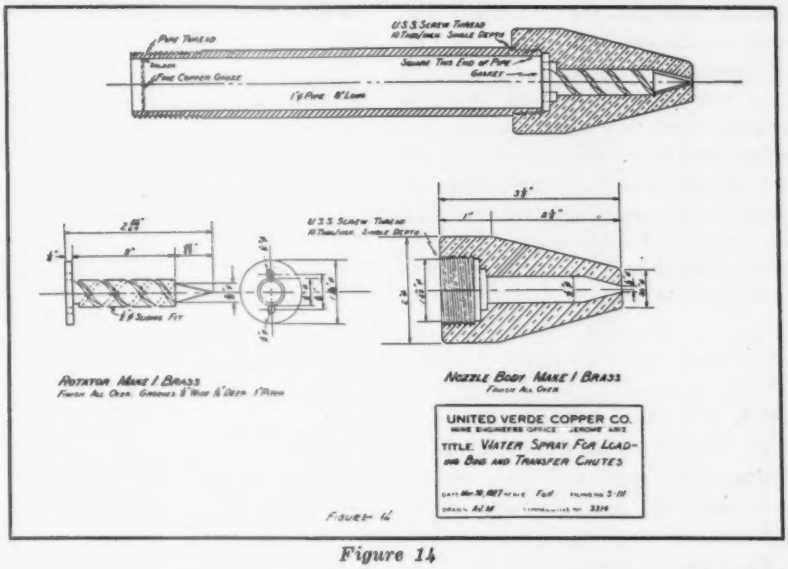


Figure 14

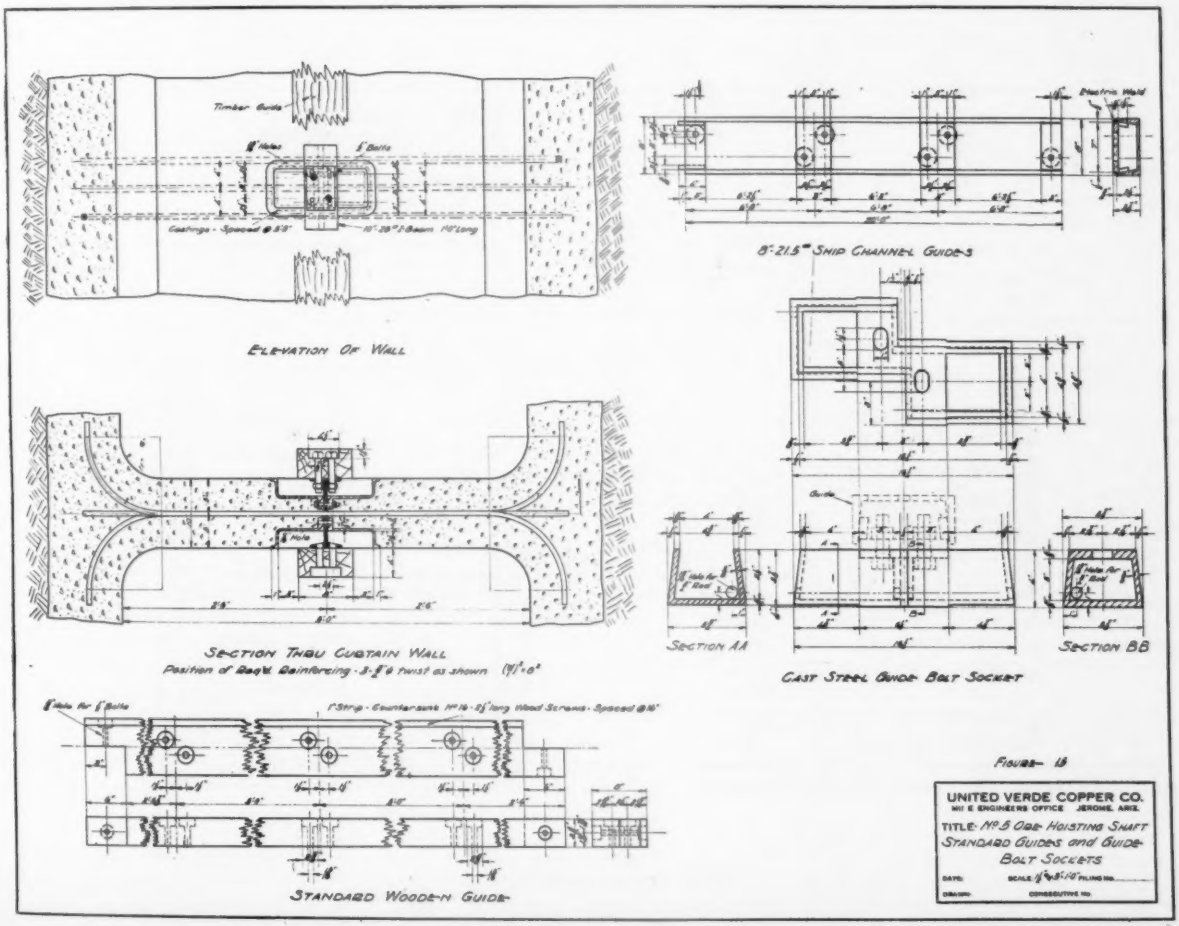


Figure 15

permit easier handling of men and supplies in and out of the skip. Because of unevenness in the track alignment, the rear axle was later pivoted to insure contact of all four wheels on the track at the same time. The rope speed is 400 ft. per minute, and, as an added precaution, angle guard rails were installed on the vertical curve at the change of inclinations to hold the skip on the rails while traveling at full speed.

The ⅞-in. hoisting cable is supported at intervals of 50 ft. by maple rollers 5¾ in. in diameter, 16 in. long with 1¼-in. axle mounted on angle clip bearings riveted to a 7-in. by 25-in. by ¼-in. plate. The plate is spiked to the foot wall plates and may easily be changed when the wooden rollers become grooved.

Three special cast iron rollers, 16 in. diameter with a 7-in. face, which slopes to a groove in the center, is used on the vertical curve. These rollers are fitted with Hyatt bearings and are mounted in an angle iron frame which is lag screwed to the wall plates on the footwall.

The loading pockets are of simple construction, the chutes being made up of ⅜-in. plate, bolted to the timber pocket and equipped with a vertical gate actuated by a 5-in. air cylinder.

The dumping device is constructed of structural steel bolted to the timber sets. A flop gate operated by an air cylinder permits dumping into either side of the pocket for handling ore or waste. This flop gate is provided with a contact switch to indicate the position of the door to the hoist operator.

YARDAGE INVOLVED IN OPEN PIT OPERATIONS

	Removed to Jan. 1, 1927	Balance Remaining	Total Yardage
Steam Shovel Yardage:			
Ore	803,354	.....	803,354
Waste	6,916,383	252,953	7,169,336
Total	7,719,737	252,953	7,972,690
Electric Shovels:			
Ore	230,391	2,145,881	2,376,272
Waste	193,106	1,207,174	1,400,280
Total	423,497	3,353,055	3,776,552
Grand total...	8,143,234	3,606,008	11,749,242

EQUIPMENT USED AT THE UNITED VERDE OPEN PIT

No.	Item	Make	Model Type	Weight, Size, etc.
1	Steam shovel	Marion	300 Full revolving	8 Cu. yd. dipper
2	Steam shovel	Osgood	120 Standard	4 Cu. yd. dipper
1	Steam shovel	Marion	28 Full revolving	¾ Cu. yd. dipper
3	Electric shovels	Bucyrus	50-B Full revolving	1¾ Cu. yd. dipper, caterpillars
5	Steam locomotives	American	0-6-0 Switcher	82.5 Tons
2	Steam locomotives	American	0-4-0 Switcher	53.5 Tons
30	Cars	Western	Air dump	25 Cu. yds.
1	Spreader	Mann-McCann		14 Ft. spread
1	Crane	Browning	30 Traction	100 Tons
2	Track shifters	Nordberg	N. Peterson	
3	Churn drills	Keystone	5 Traction	
2	Motor trucks	Kleiber		5 Ton, 4 wheels
6	Motor trucks	Mooreland	T X L 6 Wheel	10 Ton, 4-wheel drive

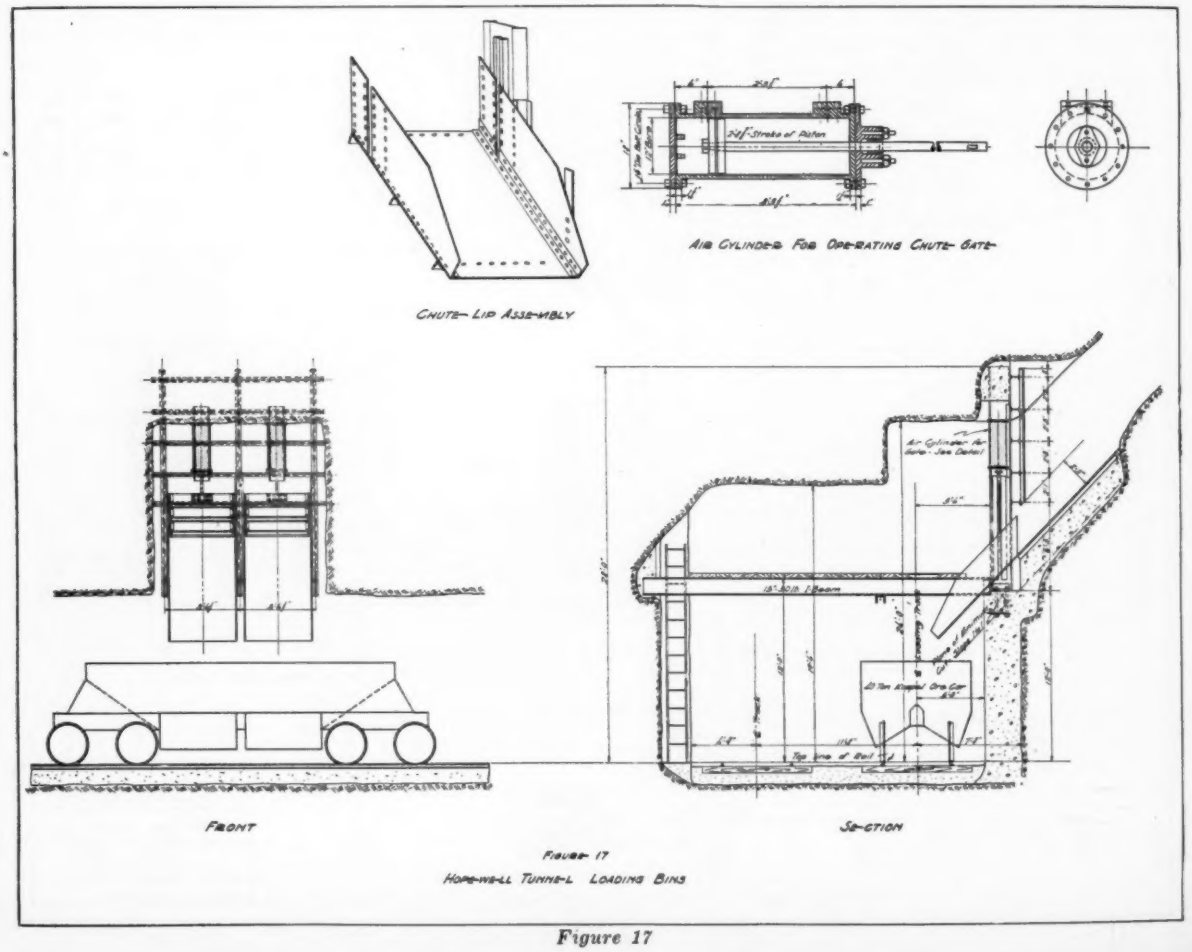


FIGURE 17
HOPE-WELL TUNNEL LOADING BINS

Figure 17

General View of Shovel Pit

Shovel Mining

The upper portion of the mine has been on fire since 1894, and prior to 1916 the ore within this area was mined at a high cost, under the Plenum system.

In 1919 a steam shovel program was started which called for stripping the overburden from above the 160 level by steam shovels, and the material between the 160 level and the 500 level by a combination of shovel and mill hole methods.

The yardage involved in this program is shown on the foregoing page.

Steam shovel operations were started early in 1919 and continued until November, 1920, at which time operations were suspended because of the depression in the copper market. Operations were again resumed in February, 1922, and the major portion of the stripping which lies above the 160 level is now completed and all future shovel mining will be by electric shovels and motor trucks.

The tabulation on the foregoing page lists the mechanical equipment used in the shovel program.

Stripping operations consisted of removing approximately 7,000,000 cu. yds. of waste from above the 160 level by eight major benches. The first bench above the 160 level was 110 ft. high, while the others averaged 50 ft. in height each. Eleven miles of switchbacks connected the various benches and provided dump track for the disposal of the waste.

Mining on 50-Ft. Benches

The waste material adjacent to the ore bodies consisted largely of altered diorite and was easily broken by churn drill methods. Holes were spaced 35 to 45 ft. apart along the bank at a distance of 30 to 40 ft. back from the toe and were shot with 10 to 12 boxes of powder. Toe holes were sometimes used in hard ribs.

As stripping operations continued to the west, fresh diorite was encountered. This rock is very hard and extremely difficult to drill and blast. Machine drilling and blasting was resorted to. Ingersoll-Rand 248 machines, equipped with handles and suspended from pipe tripods were used to drill the vertical holes, which were spaced 10 ft. back from the top of the bank and 10 to 15 ft. apart. The depth varied from 20 to 30 ft. and the burden 16 to 20 ft. Drilling speed averaged 3.7 ft. per hour, or 12 ft. per man shift with a labor cost of $0.42 per ft. The power charge averaged 112 lbs. per hole. Toe holes were used in combination with the vertical Leyner holes. They were drilled with Sullivan D. P. 331 jackhammers and averaged 18 ft. in depth. They were spaced 6 to 15 ft. apart and were chambered with 35 percent gelatin and then loaded by means of a compressed air gun. Machine drilling and blasting in the altered diorite cost 14 cents per cu. yd. for labor and explosives. This increased to 18 cents per cu. yd. for machine drilling and blasting in the hard diorite. Shovel yardage averaged 760 yds. per 8-hour shift compared to 800 in the soft diorite.

Mining of 110-Ft. Bank

The initial cut was started on the 160 level and consisted of a thorough cut 100 ft. wide to open up the ore raises extended up through the mine in order that any ore encountered in the stripping operation could be handled through the mine. The 300 Marion, equipped with a 80-ft boom worked successfully against this height bank. Churn drill holes were drilled as close to the edge of the bank as possible and to a depth of 10 to 15 ft. below grade. The average burden at the toe averaged 55 ft. The powder charge varied from 4,000 to

8,000 lbs. and was loaded by means of an inclined trough which permitted the men to stand at some distance from the collar of the hole.

Practically all the holes in the vicinity of the ore area were hot from the fire zone beneath and temperatures ranged from 100 to 240 degrees F. These holes were alternately sprung and cooled with running water until sufficiently cool to load with gelatin powder and then shot by electric detonator and Cordeau.

Coyote Mining

Because the cut on the 160 level was made and widened out much sooner than the stripping could possibly be done on the 50-ft. benches above, the southwesterly slope was consolidated into one 320-ft. slope and the breaking accomplished by coyote methods.

Six coyote shots were successfully carried out and furnished 893,000 cu. yds. of waste at an average cost of $0.172 per cu. yd., including all development, labor, supplies and explosives. The yardage broken by the individual shots varied from 54,000 cu. yds. to 259,000 cu. yds. The powder charge varied from 5,000 lbs. of 60 percent ammonia and 45,000 lbs. of quarry Special No. 4,—to 9,900 lbs. of 50 percent gelatine and 250,000 lbs. of black powder. The average yardage broken per pound of explosive for the six coyote shots was 1,035 cu. yds.

The average stripping costs for the year 1925 were as follows:

STEAM SHOVEL STRIPPING COSTS

Machine drilling and blasting:	
Labor	$0.095
Explosives	0.078
Supplies	0.009
Compressed air	0.010
Repairs	0.024
Total	$0.216
Churn-drilling blasting:	
Labor	$0.006
Explosives	0.010
Fuel	0.003
Supplies	0.002
Repairs	0.003
Total	$0.240
Steam-shovel operations:	
Shovel labor	$0.034
Pit labor	0.020
Fuel	0.044
Supplies	0.007
Repairs	0.108
Total	$0.213
Locomotive tramming and dispatch:	
Labor	$0.057
Fuel	0.045
Supplies	0.005
Locomotive repairs	0.020
Car repairs	0.031
Track maintenance	0.053
Dump expense	0.049
Total	$0.260

The ore zone at the 160 level is approximately 600 by 1,100 ft. in cross section, and roughly lenticular in shape. The limited size of the pit does not permit spiraling down with tracks and necessitated the driving of a system of ore raises from the 1,000 haulage level to the surface, to permit passing the various

Figure 18—50-B Electric Shovel Loading Dump Truck

classes of ore to the loading bins on the level for transportation to Hopewell bins. The ore is passed through grizzleys on the 900 level, these grizzleys being of very heavy construction with 15-in. openings.

There are six classes of ore, each requiring separate routing to the smelter or stockpiles, viz, direct smelting, milling ore, leaching ore, oxide, converter, low-grade silica and waste. A mill hole system was impractical because it was impossible to drive raises at regular intervals through the fire country and because of difficulty of clean mining in mill hole work. Small electric shovels and motor truck transportation offered the best solution and the necessary flexibility in a pit of limited size and where several different classes of ore or waste need be handled each day.

The Bucyrus 50-B electrical shovel mounted on caterpillars was selected as being most suited to conditions. Refer to Fig. 18.

DESCRIPTION OF 50-B SHOVEL
(Caterpillar Mounted)

Length boom	30 ft.
Dipper handle	17 ft.
Dipper capacity	1¾ cu. yds.
Maximum dumping radius	31 ft.
Maximum dumping height	18 ft. 3 in.
Total weight	120,000 lbs.
Size hoist motor	100 h. p.
Size swing motor	40 h. p.
Size thrust motor	30 h. p.
Current	3 phase, 60 cycle, 440 volt a. c.

This shovel is also provided with an electric dipper trip mounted on the dipper handle, enabling one man to operate the shovel satisfactorily.

Data on electric shovel operations during the first three months of 1927 is given as follows:

DATA ON 50-B ELECTRIC SHOVEL OPERATION
January, February, March, 1927

Average yardage per month	34,297
Average shovel shifts per month	66.7
Yardage per shovel shift	514.9
Percentage delays	19
K. w. hrs. per cu. yd.	1.14
Cost Per Cubic Yard	
Shovel labor	$0.037
Pit labor	0.001
Bonus	0.014
Supplies	0.001
Electric power	0.018
Repairs	0.063
Total	$0.140

Motor Trucks

Both four-wheel and six-wheel trucks were tried out in the pit and at present two Kleiber 5-ton trucks and six Mooreland 10-ton, four-wheel drives are in operation. The four-wheel drive has proven advantageous with heavy loads, particularly in wet weather, and all future truck equipment will be of this type. The trucks are provided with boiler plate cab and radiator protector and the frames are heavily reinforced.

The dump body is the side-dump type and the design was worked out and the bodies built at the mine plant. The box is of the V type and has a capacity of 6 cu. yds. full. It dumps and rights itself by gravity. The lugs which release the body are connected to a lever in the cab in order that the driver can dump the load without leaving his seat. Fig. 19 shows the construction of this dump body. The cost of such a body is approximately $800.

Data and costs on motor truck operation during the first three months of 1927 is shown in the following table:

Figure 19—Mooreland 10-Ton Truck with Dump Body

DATA ON MOTOR TRUCK OPERATION
During January, February, and March, 1927

Average yardage per month....	19,728
Average truck shifts per month.	178
Average yardage per truck shift.	112.9
Truck shifts per shovel shift...	2.67
Average load per trip.....	3½ cu. yds.
Average tonnage per trip.....	10 tons iron
Average tonnage per trip.....	7 tons converter
Cu. yds. per gal. gas.....	12.2

Cost Per Cubic Yard

Labor	$0.078
Supplies	.027
Repairs	.161*
Total per cu yd.	$0.266

* Note—The cost of repairs is higher than it normally would be, because the cost of equipping trucks with bodies was charged to operation.

Drilling and Blasting

Machine drilling and blasting is used in ground outside of the fire area, but has not proven successful in hot ground because of the difficulty of cooling the toe holes prior to shooting. Toe holes in hot ground must be shot with torpedoes which are made up of 1½-in. cardboard tubing, 4 to 8 ft. in length and filled with 35 percent gelatin. They are primed with a No. 8 electric detonator, rammed down the hole and shot before the powder becomes ignited by the heat of the ground. If more than one hole is shot at a time, each torpedo is handled by one man. This method of blasting in hot ground has been largely replaced by churn drilling and blasting, which offers better opportunity for cooling the hole before loading.

The average cost for drilling and blasting during the first three months of 1927 was $0.284 per cu. yd. for the 50-B shovel operations.

Bonus

All pit labor is performed under the bonus system wherever possible. The 50-B electric shovel crews consist of runner, oiler and pitman, and the base rate for each crew is 250 cu. yds. per 8-hour shift, no delays being allowed under this rating.

The truck drivers' bonus is not an individual rate, but is based on the average bonus paid the shovel operators.

The base rate for the powder gangs is on a yardage basis, the rate varying from 12 to 24 cents, depending on ground classification. This figure includes labor only.

Churn drilling rates will vary from 1 to 2 ft. per hour per churn drill shift, and the cost of this drilling without the bonus is charged in against the powder gang on the drilling and blasting bonus costs.

Gases

Sulphur dioxide gas from the fire stopes below give considerable trouble in the pit. This is particularly true of ground that is being excavated. The gas is almost entirely sealed off from the floor of the pit by packing of the ground by operation of the trucks and shovels over it. Fine sulphur dust caused by loading the partly calcined ore is as troublesome as the gas itself and each man is provided with a small respirator.

A 3-in. Krogh sand pump has been installed to pump slimes in the shovel workings to seal off the fumes from the fire area below. Mill tailings from the concentrator at Clarkdale are shipped up in tank cars and sluiced into a storage tank. From here it is pumped into the pit as needed. This scheme has proven satisfactory and a milling plant will be installed on the 160 level to slime low grade porphyry ore, and a systematic campaign will be conducted to seal and extinguish the fire which extends to the 700 level of the mine.

IMPROVEMENT IN LEACHING METHODS

A METHOD for the agglomeration of the slime and fine particles in the leaching of ores, discovered as the result of experimental work at the Southwest Experiment Station of the Bureau of Mines, Tucson, Ariz., is considered to hold promise of wide application in the metallurgy of copper and other ores. Hundreds of millions of tons of tailings from copper concentrators, too low grade for treatment by other processes offer possibilities of successful treatment by this method.

Under the newly discovered method, the slime and fine particles can be agglomerated and the state of agglomeration maintained in such a manner that masses of ore containing finely divided material can be made permeable to downward trickling leaching solutions, provided open drainage is maintained at the bottom and that the solutions are not allowed to pool on the surface.

In the process of agglomeration the slimes are caused to adhere to the larger particles or cohere together. To accomplish this the dry crushed ore or other material is moistened with water or leaching solutions simultaneously with mixing until the desired agglomeration is attained. Surface tension, capillarity, and other surface forces will cause the agglomerated particles to hang together and permit diffusion of the leaching solution as films throughout the charge. It is necessary to have a top layer of ore without slimes to get an even distribution of solution and prevent disintegration of the aggregate particles.

Experiments have shown that the increase in possible percolation rate produced by agglomeration with open drainage is between 5 and 40 times, depending upon the character and proportion of the slimes present. Also by this method advantage can be taken of oxygen from the atmosphere entering into the chemical reaction of leaching.

The development of this principle should make it possible to treat finely divided ore or tailings by heap leaching principles, and thus avoid costly tank construction.

Enormous tonnages of tailings from copper concentrators have accumulated in the country. This finely divided material contains from .2 to nearly 1 percent copper. At many places this copper is amenable to leaching, but the treatment by present practices is too costly for the grade of the material. Should the principle of agglomeration prove practical, much of the copper now tied up in the tailings piles can be made available for use. The method is also particularly applicable to ores that tend to slime in crushing or which require relatively fine division to liberate the values.

Laboratory tests have indicated that the leaching of agglomerated material by the open-drainage principle does not necessarily require longer time of contact with the leaching solution than does standard vat leaching. Under proper conditions this method has shown more rapid leaching and better washing than when the ore is flooded with solution.

A detailed description of the method, covering laboratory and test plant results, is to be published by the Bureau of Mines in the near future.

Fig. 1. General View of Mine, Utah Copper Company, Bingham, Utah

ELECTRIC SHOVEL OPERATION AT UTAH COPPER MINE*

Original Steam Shovel Equipment Capacity Increased And Caterpillars Installed—Electric Shovels Introduced—Superiority Of Electric Installation Unquestioned—Power Factors Discussed—Comparative Steam And Electric Costs

By C. W. CORFIELD† and R. J. CORFIELD‡

THE Utah copper mine is in reality a mountain of low-grade copper ore, covered by an overburden of decomposed rock, varying in depth from 75 to 200 ft. Figure 1 is a photograph showing the clearly defined levels, or benches, which vary in height from 70 to 130 ft. and have a slope of approximately 45 degrees. Some of the levels are very narrow at the ends and gradually widen toward the center. The ore, after being blasted from the banks and loaded, is transported to the main assembly yard over a series of switchbacks built, in most cases, with an average grade of 4 percent. Figure 2 is a map showing a part of the haulage system. Both the ore and waste break rather easily and the blasted material varies from gravel size to very large boulders, which, if too large to go in the dipper, have to be separately blasted before loading. The material in its blasted condition, ready for loading, weighs approximately 4,160 pounds per cubic yard.

TYPES OF LOADING EQUIPMENT

The first steam shovel was put in operation in 1906, and more were added as conditions warranted. The original shovels were equipped with railway type trucks and 2½ cu. yd. dippers. These dippers were later replaced by 3½-yd. dippers and some caterpillars were installed, later all steam shovels were equipped with 4½-cu. yd. dippers and caterpiller tractors. Figure 3 shows the first steam shovel at Bingham. The first electric shovel appeared in 1922, at which time two, Marion Model 92, were purchased, both being equipped with caterpillar tractors and 4½-cu. yd. dippers. One of these shovels was driven by direct current motors, while the other was equipped with alternating current motors of the mill type. Rather extensive tests, both electrical and capacity, were made on these two shovels and either of the electrics proved to be far superior to steam shovels and considerable increase in economy was shown, together with a great many operating advantages that could not be capitalized. In 1923 eight additional shovel equipments, using alternating current motors, were ordered, and eight shovels were converted from steam to electric drive. After these shovels had been in operation for a sufficient time to prove their superior operating economies, other shovel equipments were ordered, until at the present time there are 23 electrics operating and no steamers. Nine of these shovels are equipped with alternating current motors, with rheostatic control, and 14 with direct current motors, using the Ward-Leonard system of control, modified to meet the particular kind of service which is very severe and requires the most rugged motors and control equipment. Figure 4 is a view of a modern electric shovel.

* Presented at meeting of Western Division, The American Mining Congress, Salt Lake City, Utah, August, 1927.

† Electrical Engineer, Utah Copper Company, Bingham, Utah.

‡ Assistant Electrical Engineer, Utah Copper Company, Bingham, Utah.

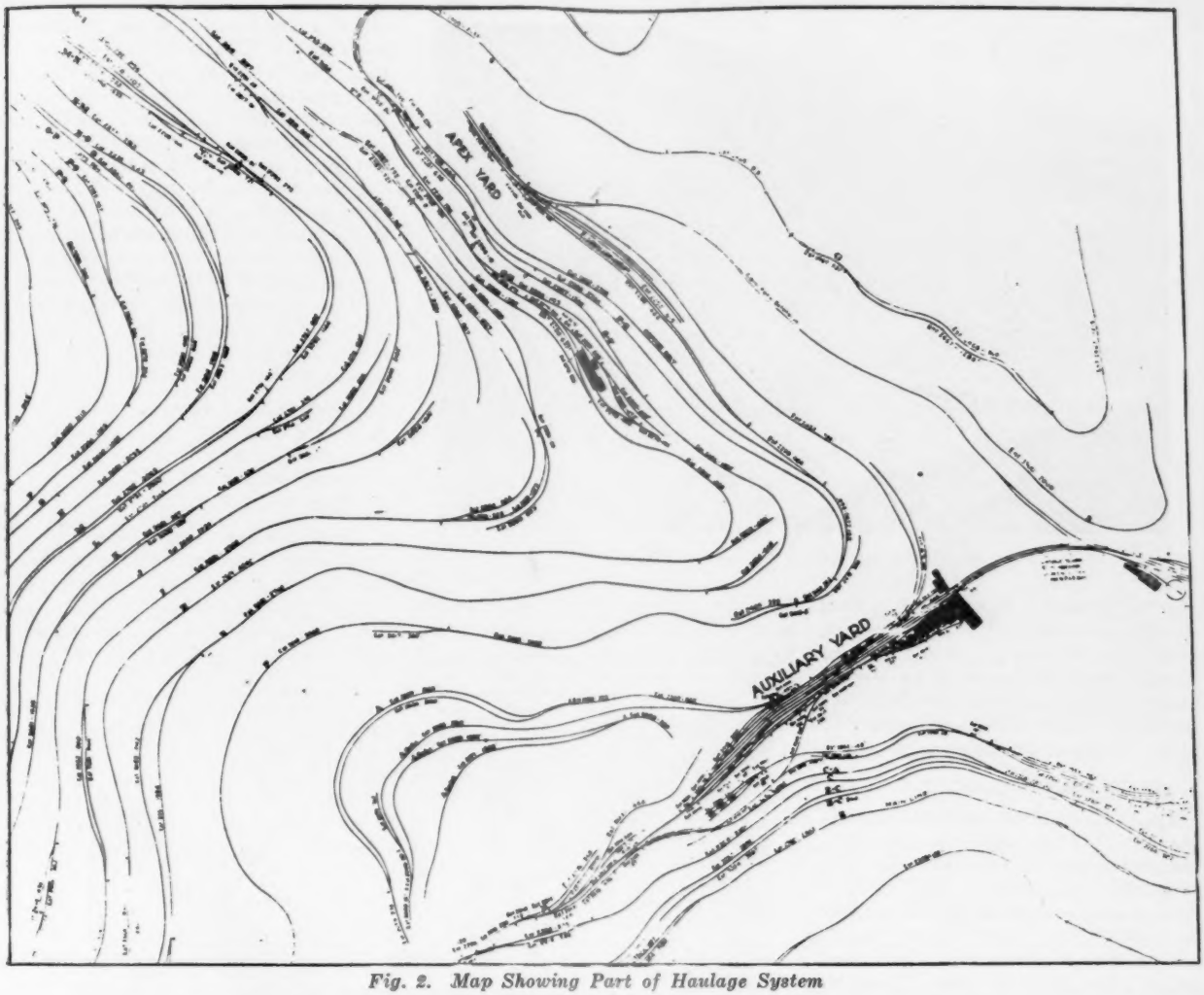


Fig. 2. Map Showing Part of Haulage System

Shovel Characteristics

The electric shovel is primarily designed to replace the steam shovel which, were it not for its poor economy and high maintenance, has an ideal control characteristic; therefore an electric shovel should be designed with a type of control that will duplicate the steam characteristics as nearly as possible.

A curve showing the comparative characteristics of steam, alternating current, and direct current drive, is shown in Figure 5, and it should be noted that the Ward-Leonard system of control approaches very closely to the steam characteristic, giving the necessary smoothness and flexibility. Three types of direct current motors are available for shovel drive, i. e., shunt, compound, or series wound. Which of these motors is best adapted for shovel drive depends on the nature of the material handled and the speed requirements. In general, it may be said that the saparately excited, compound wound motor is best suited for general application to railway type shovels. Typical graphic charts showing the power required, peaks, and the general character of the duty cycle, are shown in Figure 6, for the alternating current equipment, while Figure 7 shows the corresponding curves for the direct current equipment. These curves are intended to be typical and not comparative, as a number of almost impossible conditions must be realized before comparative curves can be made, i. e., character of material, personnel of crew, and condition of equipment must all be equal. These curves indicate the severity of the duty cycle and show clearly the necessity for using the most rugged type of electrical equipment available. It should also be noted at this point that the electrification of shovels has been directly responsible for an improved mechanical shovel, as the torques obtained from electric motors is greater than from steam engines, making it necessary to strengthen the underframing, gearing, and other structural parts of the shovel. This increased strength and ruggedness means fewer mechanical delays and hence is a contributing factor in electrification economies.

Electrification has also fostered a close relationship between the shovel manufacturer and the electrical equipment manufacturer, with the result that the electric shovel in its present form is a highly coordinated and well arranged piece of equipment. The shovel operator has also had an important part in this development in suggesting certain changes in both mechanical and electrical equipment. Tests, extending over a period of months, or even years, are necessary before practical conclusions can be drawn. During this period, power costs, tonnage loaded, repairs and operating time, must be tabulated. Such a tabulation, showing comparative operating costs of electric and steam shovels, is shown in Table 1, and a comparison of the data is interesting, from an operating and engineering standpoint. About half of the savings shown is due to electrification while the other half is due to the substitution of caterpillar traction for railway trucks. It should be noted

Fig. 3. First Steam Shovel at Bingham

that the tabulation does not include fixed charges on either type of equipment, and while it is hardly expected that the electric drive will ever be as low as steam in first cost, economies and other advantages outweigh the advantages of steam equipment in this respect.

Loading Capacity

The electric shovel is capable of loading more ore per shift than its steam competitor, due to the fact that it is practically impossible to keep up uniform steam pressure, delays due to leaking steam and water lines, choked boilers, etc., also contribute. Individual cycles, timed by stop watch, show the steam shovel to be just as fast, and in some cases faster, than the electric, but the fast cycle can not be repeated over the day's work, for the reasons outlined above. On the other hand, the present electric shovel is a highly developed and simplified machine, and while electrical delays occur, they are usually due to control equipment that can be repaired very quickly and in a great many cases are of such a nature as not to seriously affect the operation of the shovel, and can be left until the shift is completed. The loading capacity of the electric is roughly 14 tons per minute, and if cars were available, and there were no delays, it would be possible to load 6,720 tons per shovel shift, or a total tonnage of 154,560 tons with 23 shovels. However, as the operating time factor averages about 80 percent, and cars are not always available, this tonnage is reduced to about 105,000 tons maximum per day. The ore tonnage varies from 35,000 to 50,000 tons per day, while the waste tonnage varies with the mine development. The economic balance between ore mined and waste moved, together with the problem of waste disposal, requires excellent judgment and foresight on the part of the mine operators, and plans have to be made for several years in advance, and adhered to as closely as possible.

Fig. 4. Modern Electric Shovel

Power Supply and Substation Capacity

Electric power for the operations at Bingham is furnished by the Utah Power & Light Company. The power is received at the Magna Central Station at 120,000 volts, where it is transformed through two banks of transformers, rated at 25,000 K. V. A. per bank, to 44,000 volts. A three-phase line of No. 2 copper, 14 miles long, extends from Magna to Bingham. This single line merges into a two-circuit line at Bingham, and these two lines feed the two shovel substations, which are duplicates and shown in Figures 8 and 9. Each of these substations contains six, 400 K. V. A., transformers. At these substations the voltage is reduced from 44,000 to 5,500 volts. Suitable oil circuit breakers and relays are installed on both sides of the transformers, together with disconnecting switches, so that any unit may be disconnected from the bus bars with a minimum of delay. There are a number of factors that must be carefully considered when designing substation and transmission systems for supplying power to a fleet of electric shovels, the most important of which are:

Continuity of Service.
Spare Capacity.
Load Diversity.
Power Factor and Peaks.
Voltage.

The first of these can be taken care of by selecting standard transformers and switchgear, together with necessary disconnecting equipment and adequate relays. The proper bus spacing and line connections are also important. In general, the outdoor type of substation is desirable for mining properties where conditions are rapidly changing and there is a possibility of having to move the shovel substation as the work progresses. The problem of spare capacity is closely linked with that of load diversity, in that diversity must be considered in arriving at transformer capacity. Where a large fleet of shovels is involved, enough spare capacity should be provided to care for the assumed worst possible condition, which in this case has been taken as a complete bank of transformers out of service. Another question to consider is the constant shifting of the load center, i. e., for a certain set-

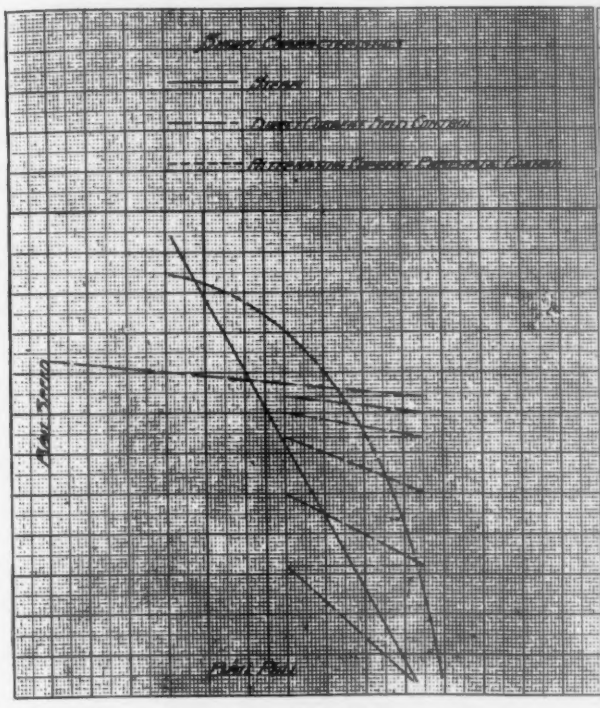


Fig. 5. Comparative Shovel Characteristics

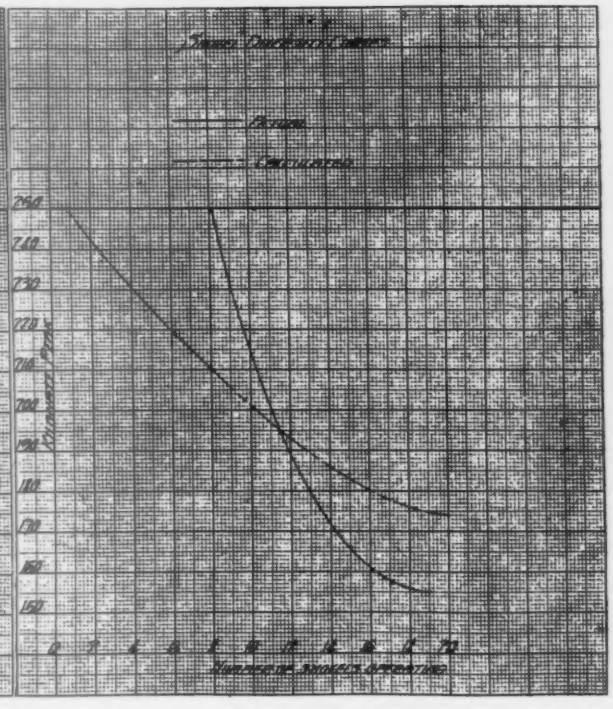


Fig. 10. Shovel Diversity Curve

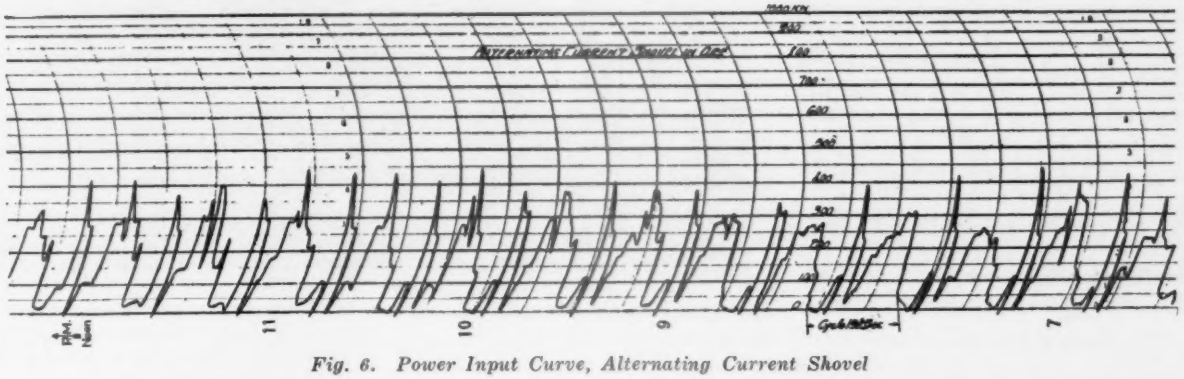


Fig. 6. Power Input Curve, Alternating Current Shovel

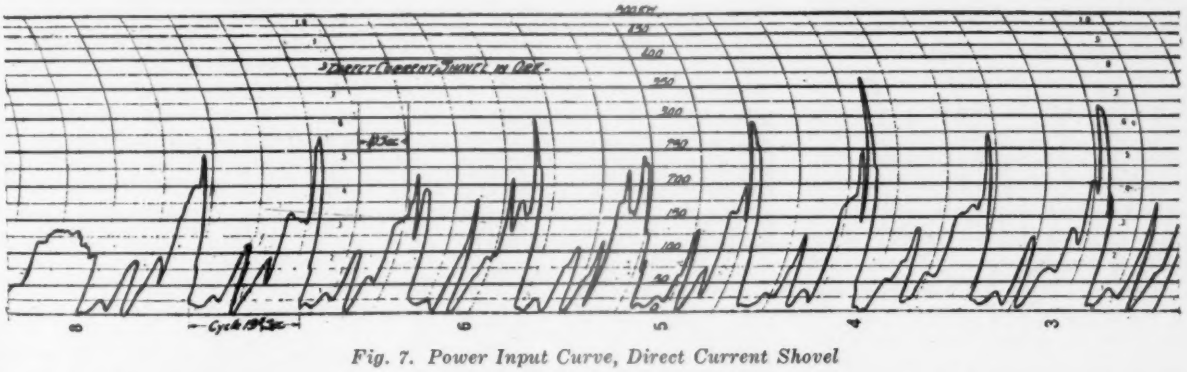


Fig. 7. Power Input Curve, Direct Current Shovel

up of shovels one substation may be called on to carry more than its average proportionate share of the load, while the other substation will be carrying less than its proportionate load, in which case it is not only necessary to parallel the transformer banks at the substation but to operate the two substations in parallel also.

This condition is avoided as much as possible as quite a network of secondary distribution is involved and the protection afforded by the relays becomes problematic. In general, it is advisable to have more transformer capacity than theoretically necessary on loads of this nature. The problem of diversity is difficult to solve, and various methods were used in trying to arrive at a true solution. The problem was further complicated in that the characteristics of

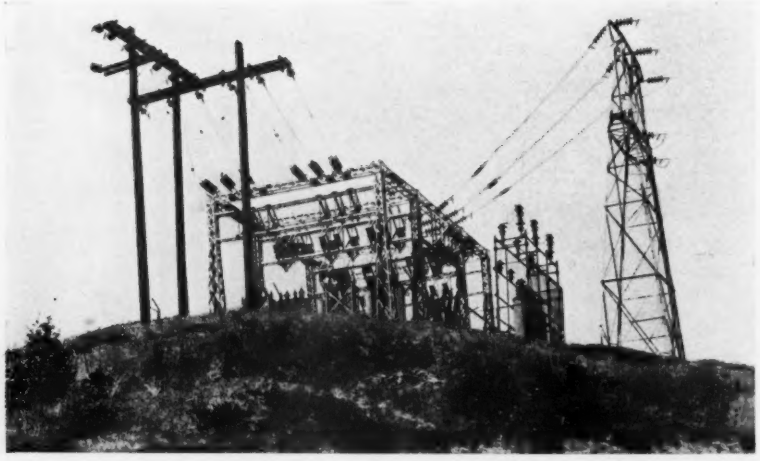


Fig. 8 (above) and 9. Shovel Substations

the two types of electrical equipment are different electrically and no final decision could be made as to the type that would finally be adopted, with the result that both types are being used. A calculated peak diversity curve is shown in Figure 10, and superimposed on this curve is an actual curve, plotted from meter readings taken at times when only certain shovels were working. When the number of variables effecting diversity are considered, the theoretical curve is not so much in error, and fortunately the error is on the right side, i. e., the theoretical curve is higher than the actual for all points above 12 shovels, and as there are always more than 12 shovels working during the day shift, and seldom more than six during the night shift, no trouble due to overloading has occurred on the transformers.

Power Factor and Peaks

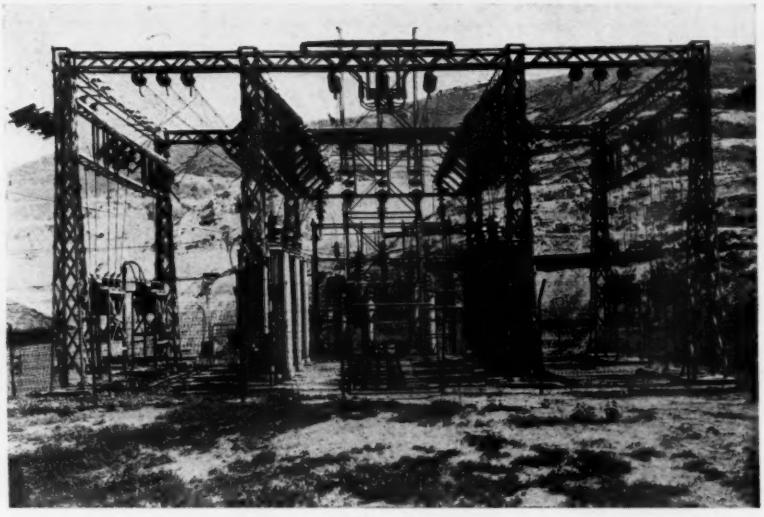
The questions of power factor and peaks have an important bearing on the transformer capacity and distribution systems. The power factor of the direct current equipment may be made anything from unity to 70 percent, leading, while the average power factor of the alternating current equipment will not be greater than 65 percent, lagging. The peaks with alternating current equipment, in hard digging, will be about 450 kilowatts, while the corresponding peak on the direct current equipment will be about 250 kilowatts. These peaks are only momentary and do not increase the power used on the total cycle by this ratio, the relative ratio being about 18 percent in favor of the direct current equipment. These high peaks and low power factors do, however, influence the size of the transformers and the size of the copper required to transmit power to the shovels.

Voltage

The best voltage to use for the secondary distribution system depends on the type of electrical equipment used, and is really a study in economics. With alternating current equipment, line regulation is important as low voltage at the shovel results in excessive heating. The direct current equipment, with its synchronous motor generator set, is not influenced to any great extent by fluctuating voltage. If cables are to be used as transmission lines across the levels, low voltages are preferable, as high voltage cables, subject to constant handling and reeling, do not show a very long life. The question of splicing high voltage cables is important and requires very careful consideration. In general, a standard voltage of as low a pressure as is economically possible should be used.

Secondary Distribution

Power at 5,500 volts is carried from each substation over two single circuit, wood pole lines, which are arranged to encircle the entire mining area. These lines are carried as close to the ends of the levels as possible, and with this system of distribution, it is possible to feed any level from any of four secondary trunk lines. Such a distribution system may appear rather elaborate, but when it is considered that a large fleet of shovels would be delayed in case of electrical trouble of any kind, and that delays are very costly, it is evident that a dependable system of distribution is not only justified but is absolutely essential. As previously stated, continuity of service is the most important single item to be considered, and as transmission lines



over a mining property are subject to blasting, train derailments, and landslides, it is advisable to build these lines in duplicate, and to proportion them in such a way that one line will carry the load in case the other line is out of service for any reason. Taps are taken from these main distributing lines at the ends of each of the levels. These taps are brought to a portable switch-house (Figure 11) in which is installed an automatic oil circuit breaker, together with disconnecting switches and lightning arresters. This switch is depended upon to clear electrical trouble on the levels and keep any disturbance from getting back to the substations. The question of relay settings on these circuit breakers is hard to determine, as short circuits may occur at any point from 50 to 3,000 feet from the breakers, also, the level distribution system is a composite one, i. e., aerial and cable, and is so inter-connected as to make accurate calculations difficult. However, the system in general has given excellent service,

and it has been possible to maintain power at the shovels in a satisfactory manner, in spite of the apparent limitations.

Bench Line Distribution

The problem of getting power to the shovel was a difficult one to solve, and a great deal of experimenting and development was necessary before a solution was found. It was not considered feasible to run aerial lines of any kind on the levels, due to the constantly changing nature of the bench and the danger of blasting the lines down. A three-conductor cable seemed to offer a solution and several thousand feet of cable were ordered and placed in service. This cable was rubber insulated for 7,500 volts, and the three conductors were jacketed with a tough rubber sheath designed to withstand abrasion due to reeling and unreeling over sharp rocks on the benches. This cable had only been in service for a few weeks when it was noted that very small cracks were developing in the outer rubber jacket. At first it was believed that these cracks were due to weathering and abrasion, but very soon after these cracks appeared, electrical failure developed and the cables would break down, as many as six times during a shift. The cable manufacturer was consulted and various reasons for the cable failure were advanced. New cables were furnished having a copper gauze over the individual conductor insulations. This gauze was intended to serve as a static shield, and produce a more uniform dielectric field within the cable. These cables were installed and watched very closely. The static shield increased the cable life materially but eventually these cables also failed. During this time, other cables of different makes were tried, with varying success, and it was finally decided to try a conduit line across the level, with three single conductor cables. This system, however, developed the same characteristics as the three conductor cables, except that the damage was greater when the individual conductors broke down, as holes would be blown through the conduit, making it necessary to replace conduit as well as wire.

While these various schemes were being tried an experimental aerial line was constructed, part way in on one of the levels. In this case, holes were dug and poles set in the regular way. This proved quite costly and at the same time the line could not be moved. The effects of blasting on this line were noted quite closely, showing that a great many insulators were being shattered. The wood poles were also damaged in some cases, being broken off due to direct hits. However, outside of broken poles, it was found that quick repairs could be made on this aerial line and the results of several months experimenting were so gratifying that it was decided to design a steel structure that would be strong enough to support the line, on a reasonable spacing, and at the same time be light enough to be portable. This portable steel tower, shown in Figure 12, was constructed and has since been adopted as standard for all level distribution, at a considerable saving over any other system tried. Each shovel receives power from the portable bench transmission line through a 500-foot length of trail cable. This cable terminates at a reel on the rear end of the shovel, and about 400 feet of cable is available for shovel movement, parallel to the bank. The attachment of the trail cable to the transmission line is quite clearly shown in Figure 12. On the original aerial transmission line, unbreakable, composition insulators were used, but this type of insulator would not stand up electrically under the severe weather and temperature conditions. Porcelain insulators were subject to breakage, due to blasting. This problem was solved by selecting a solid type of porcelain suspension insulator, and attaching to the end of the cross arm a light metal shield. This shield can be seen in Figure 12.

Fig. 12. Portable Transmission Tower

Fig. 11. Portable Switch House

In conclusion, it may be well to state that the electric shovel has definitely proven its superiority over steam equipment and the major problem consists in an adequate power supply, and distribution system to the shovels.

TABLE I—PROPORTIONATE COST PER TON LOADED

Steam		Electric	
Engineer	100	Engineer	100
Craneman	100	Craneman	100
Fireman	100	Electrician	51.1
Coalman	100	Elect. helper	51.8
Pitman	100	Pitman	100
Watchman	100	Watchman	0
Total oper. labor.	100	Total oper. labor.	76.2
Coal and water	100	Power	17.5
Packing and oil	100	Packing and oil.	34.0
Total op. material.	100	Total op. material	20.4
Repairs	100	Repairs	21.5
Total cost per ton.	100	Total cost per ton	37.2

ORE CONCENTRATION PRACTICE OF THE CONSOLIDATED MINING & SMELTING CO., OF CANADA, LTD.*

Present Equipment The Result Of 3½ Years Of Tests—Electric Power With Emergency Steam Turbines Installed—Capacity, 3,500 Tons Daily—Other Plants Operated—Flotation Reagents Discussed—Zinc Content Estimated Hourly By Microscopic Examination

By R. W. DIAMOND †

THREE mills are now operated by the Consolidated Mining & Smelting Co. of Canada, Ltd.: (1) The Sullivan Concentrator, Chapman Camp, British Columbia (near Kimberley, British Columbia), (2) the St. Eugene Concentrator, Moyie, British Columbia, and (3) the Tadanac (Customs) Concentrator, Trail, British Columbia. Differential flotation is the only concentration method employed in all three plants. Tables are used for pilot work only.

Values in all ores treated are as minerals of some or all of the metals—lead, zinc, gold or silver. Occasional customs ores contain small amounts of copper. Sulfide iron content of ores treated varies from a low figure in some ores to 30 percent iron in Sullivan ore. Gangue minerals vary considerably. A few customs ores are somewhat oxidized and as a result present difficulties.

Flotation equipment and control are similar in the three mills, and the flow sheets at the St. Eugene and Tadanac mills, while much simpler, are modeled after that of the Sullivan Concentrator.

In this paper I will not detail treatment nor equipment in any of our plants but will describe special features in, or in connection with, all of them. I will then deal with flotation reagents, describing our use of each of them, particularly where differing from general practice. I will conclude with comments on special subjects related to differential flotation.

SULLIVAN CONCENTRATOR

The Sullivan is a massive sulfide ore with a specific gravity of 4.35. The principal minerals are galena, marmatite, pyrrhotite and pyrite. The insoluble content is approximately 6 percent. The minerals are finely crystalline and their mixture is intimate.

Successful differential flotation of Sullivan ore commenced in the spring of 1920 in the pilot concentrator at Trail. During 1920, 193,804 tons were treated by this process. This operation continued without interruption and with steady growth. For the first seven months of 1923, which concluded the pilot plant operation, approximately 1,100 tons were treated daily. I believe the Sunnyside plant of the United States Smelting & Refining Co. was the only successful and large scale operation practicing differential flotation prior to 1920 in North America. The Sullivan ore, because of its high iron content, was quite a different problem from that at Sunnyside. The entire tonnage of Sullivan ore had to be separated into, or accounted for by three sulfide concentrate products—lead concentrate, zinc concentrate and iron concentrate.

The choice and arrangement of equipment, and the original flow sheet for the Sullivan Concentrator were controlled by the results of the exhaustive pilot mill test. These covered a continuous period of 3½ years and involved the treatment of 1,076,368 tons of Sullivan ore.

The Sullivan Concentrator, near Kimberley, British Columbia, commenced operation in August, 1923. It has been described in the technical press ‡ in the past, and while a great number of changes have been made in treatment since commencement, I will not detail them except to show the present flow sheet (Fig. 2).

Treatment

Relative to the Sullivan treatment, the following features § should be noted in the flow sheet:

1. Crushing in rolls in series in open circuit. We crush thus, from 2½ in. to "2 percent +½ in. and 50 percent

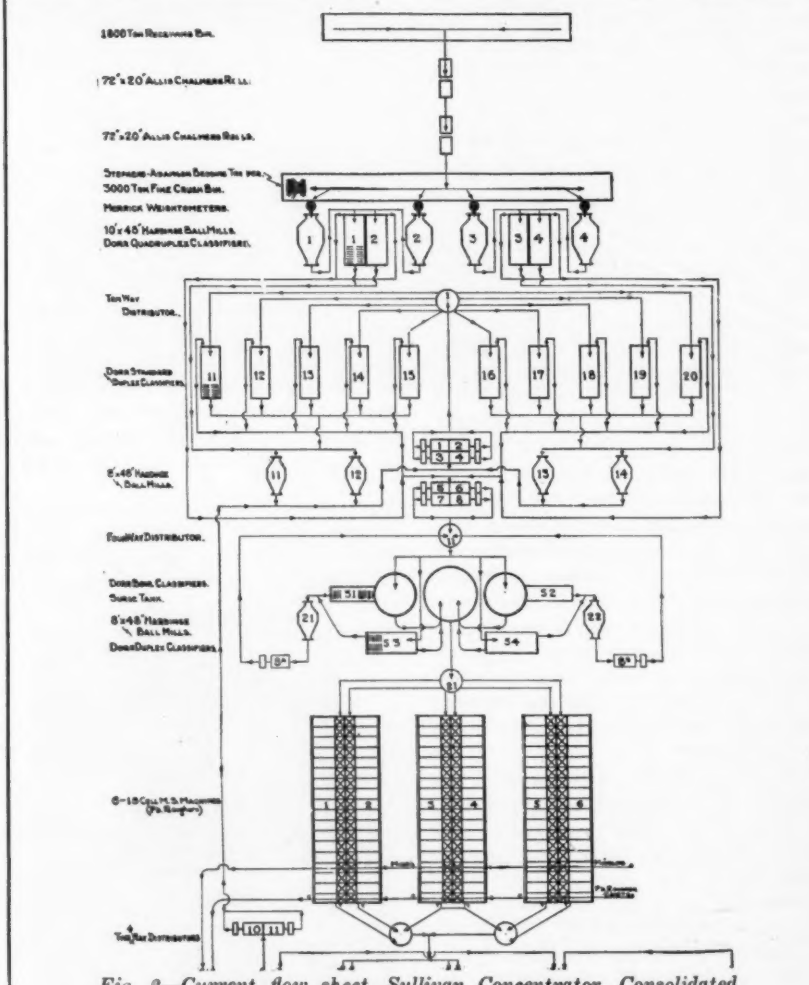


Fig. 2—Current flow sheet, Sullivan Concentrator, Consolidated Mining & Smelting Co. of Canada, Ltd., Chapman Camp, British Columbia, Canada

* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Superintendent of Concentration, The Consolidated Mining & Smelting Co. of Canada, Ltd., Trail, British Columbia.

‡ W. M. Archibald, E. G. Montgomery, E. M. Stiles, R. W. Diamond, B. A. Stummel, J. Buchanan, G. E. Murray, J. J. Fingland and S. G. Blaylock. (Staff of The Consolidated Mining & Smelting Co. of Canada, Ltd.) The Development of the Sullivan Mine and Processes for the Treatment of Its Ores. Trans. Can. Inst. Min. & Met., and Min. Soc. Nova Scotia (1924), 27, 306. (For Kimberley Concentrator, see p. 321.)

M. M. O'Brien and H. R. Banks: The Sullivan Mine and Concentrator. Trans. Can. Inst. Min. & Met., and Min. Soc. Nova Scotia (1926) 29, 100.

§ The ore is crushed to 2½-in. at the mine by 36 by 42-in. Buchanan jaw crusher, followed by two 10-in. Traylor finishing crushers.

Fig. 1—The Sullivan Concentrator, Chapman Camp, British Columbia, (near Kimberley, British Columbia)

—4 mesh," at the rate of 250 tons per hr. The ore is friable, does not pack, and has a moisture content such that dust is not a nuisance. It is possible that closed circuit with screens on the secondary rolls would be more efficient, but certainly the present operation is most simple and satisfactory.

2. Three-stage, fine-grinding to flotation feed with classification in each stage is practiced. (Flotation feed was 5.1 percent +150 mesh and 86.9 percent —200 mesh, for April, 1927.)

3. We use Wilfley pumps throughout. There are no elevators in the mill.

4. Note the separate plant for treatment of zinc flotation middling with no return to the rougher circuit.

5. We practice double-cleaning on both lead and zinc concentrate. The lead cleaner tailing is returned to the original grind, and the zinc cleaner tailing is treated in zinc middling plant. (See preceding paragraph.)

Power

Normal power is hydro-electric; 550-volt, 60-cycle current is used throughout the plant. To protect against interruption in normal power supply, three 1,500-k. w. condensing steam turbines are installed for use with the boiler plant. Normal heat for process is from live steam, but when turbines are in use the warm condenser water is used as a source of heat.

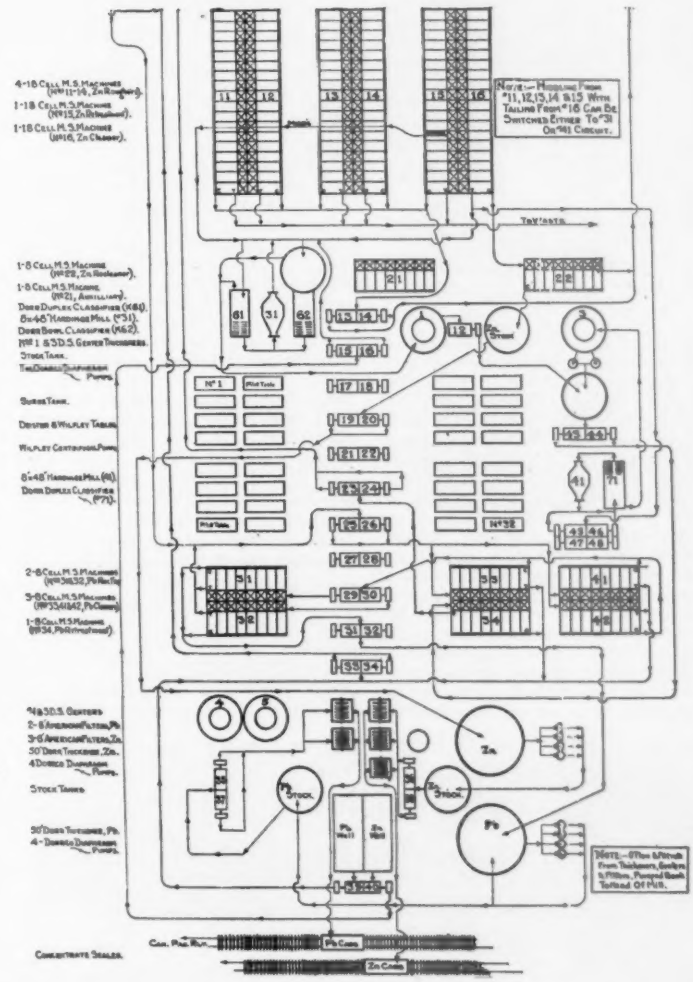


Fig. 2—(Continued)

Recovery

Very satisfactory recoveries are made from ıeed, 11.0 percent lead and 7.5 percent zinc in the form of lead concentrate containing 69 percent lead, 4.5 percent zinc, and zinc concentrate containing 3.0 percent lead and 49 percent zinc. (The pure zinc mineral in Sullivan ore is "marmatite," containing approximately 54.5 percent zinc and 10 percent iron. It is apparent, therefore, that 49 percent concentrate is high grade for this particular ore.)

Until the end of 1926 there had been concentrated by differential flotation 4,371,818 tons of Sullivan ore, and at the present time 3,500 tons are being milled daily.

St. Eugene Concentrator, Moyie, British Columbia

This plant (Fig. 3) was built during 1925 and 1926 for the treatment of gravity mill tailing from former operation. The tailing had been run into Moyie Lake and extended from the shore out several hundred feet and to a maximum depth of approximately 100 ft. The satisfactory use of a suction dredge by the Calumet & Hecla Co. for reclaiming tailing from Lake Linden persuaded us to adopt similar equipment. A 10-in. Morris suction dredge was installed which discharged into a shore pond for dewatering, over which pond and adjoining mill bin a derrick with clam shell was operated. The reclaiming procedure and equipment have proved most satisfactory.

Approximately 650 tons are treated daily. Concentration treatment consists of fine grinding and differential flotation. Splendid recoveries are obtained from feed containing approximately 2.5 percent lead and 3.5 percent zinc in the form of lead concentrate containing 73 percent lead, 3.5 percent zinc, and zinc concentrate containing 1.5 percent lead and 52 percent zinc.

Tadanac (Customs) Concentrator, Trail, British Columbia

The first unit of this plant was built in 1917 for concentration experiments on Sullivan ore. Gravity work and the Horwood process were thoroughly investigated but were abandoned. A wet magnetic concentration method was developed and a 150-ton plant built adjacent to the flotation unit. The wet magnetic plant was later extended to 600 tons daily capacity. In the spring of 1919 some success was met with in laboratory differential flotation separation. Many difficulties were experienced and investigations forced before commercial trial in the spring of 1920. Operation on Sullivan ore until August, 1923, has been described previously in this paper.

This plant (Fig. 4) commenced operation as a customs concentrator in the summer of 1925. During 1926, 81,215 tons of customs ore from 49 different mines were milled, and present operation is about on the same scale. The flotation practice and control are similar to that at the Sullivan and St. Eugene mills, and the business is conducted in a manner similar to that of the customs mills in the Salt Lake Valley.

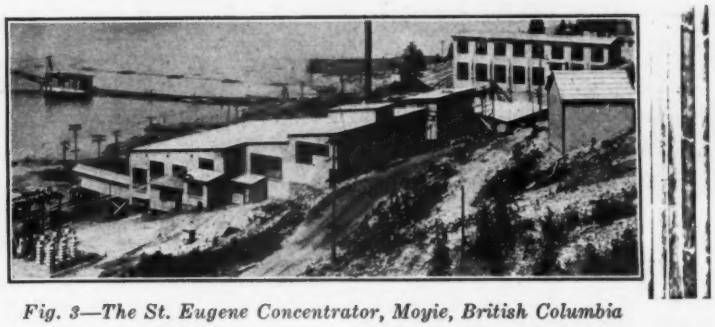


Fig. 3—The St. Eugene Concentrator, Moyie, British Columbia

Flotation Reagents

A list of our "more or less" standard flotation reagents follows: Soda ash, copper sulfate, cyanide, cresylic acid, water gas tar, coal tar creosote, xanthate, sodium bichromate, steam. In addition, or as substitutes, we use at times on certain ores, one of the following: Zinc sulfate, sodium di-basic phosphate, fumol.

Soda ash is used in the three mills as a conditioning and alkaline reagent. Caustic soda and lime have been found unsuitable in our operations to date. The quantity of soda necessary for good work varies with the character of the ore being treated, our range being from 1 to 10 lbs. per ton. The demand is usually constant with each ore. Tailing solution can generally be returned for soda and heat saving together with thickener overflows and filtrates into the circuit without noticeable fouling.

Copper sulfate is used in the zinc flotation feed in quantities ranging from 0.2 to 1.5 lb. per ton as demanded by the ore being treated. The demand is usually constant for each ore.

Cyanide is used as a zinc-iron depressant. On some ores as little as 0.05 lb. per ton is sufficient, whereas on others up to 0.3 lb. per ton or even higher is desirable. For retreatment of flotation zinc middling high cyanide up to 1.5 lb. per ton is often advantageous, making possible a lead float from the zinc flotation middling. In all cases the cyanide consumption of the ore is greatly in excess of the amount used. There are cases where disadvantages from the use of cyanide more than offset the advantages, such as: (a) Gold ores or base metal ores containing gold where solution loss of gold results; (b) cyanide has a depressing effect upon silver when associated with gray copper (tetrahedrite) and since high silver recovery in the lead concentrate is desirable, cyanide as a reagent is often objectionable with ores of this nature.

Cyanide, patented by Sheridan and Griswold, as a zinc and iron depressant, was adopted for Sullivan ore treatment and has been in continuous commercial use since January 8, 1923, which I believe was prior to its regular use by any other plant. It was, of course, discovered, and its merit established, in the Timber Butte Laboratories, and its use by us has been under license.

We use cresylic acid and water gas tar for practically all of our ores. While we still use a small quantity of coal tar creosote, a mixture of cresylic acid and water gas tar could be satisfactorily substituted. To date we have been unsuccessful in supplanting the above oils at the Sullivan Concentrator by xanthate or other reagents to advantage in spite of the accumulation of evidence elsewhere in favor of the more recent chemical reagents. Our preference for the old oils is due to their giving at least equal, if not better results, and to their being less sensitive to slightly changing conditions.

Xanthate is used only to a negligible extent in the zinc middling retreatment plant at the Sullivan Concentrator. On the St. Eugene and customs ores it is a valuable and important reagent as used in the usual way.

Sodium bichromate is used by us only at the Sullivan Concentrator. It may have particular application to this ore because of its high iron content; 0.1 lb. per ton is used in the zinc flotation feed. Bichromate has a stabilizing effect upon the zinc float and tends to offset effect upon zinc flotation of varying lead flotation conditions. Those intimate with differential flotation plant control know that lead flotation conditions have to be changed from time to time and that these changes often have an effect on the ensuing zinc flotation. Bichromate tends to nullify these effects. It is believed also that it enhances slightly zinc concentrate grade and zinc recovery.

Heat

We heat zinc flotation feed to 30° C. on most ores, including Sullivan ore. Splendid zinc results, however, are secured on St. Eugene ore when floated cold, and this is normal practice.

Zinc Sulfate

Sustained investigation of this reagent in conjunction with cyanide with most of our ores shows little, if any, advantage over the use of cyanide singly. This may be due to the usual high iron content of our ores. We have exceptions, however, among the customs ores where the combination is desirable. The use of zinc sulfate without cyanide as a zinc depressant is of particular interest on two of our customs lead-zinc ores. These contain some gold. Cyanide is objectionable. Zinc sulfate is more effective as a zinc depressant than cyanide alone or than the cyanide-zinc sulfate combination. Incidental to the use of zinc sulfate alone as above there is noticeable a considerable increase in oil consumption.

Sodium dibasic phosphate is used for certain customs ores as an alternative for soda ash. Its use in place of soda probably slightly increases silver recovery in the lead concentrate.

Fumol is used as a frother for the iron float following zinc flotation on certain customs ores.

Comments on Special Subjects

1. *Effect of Grinding Conditions on Differential Flotation.*—It is generally known that in the usual closed circuit ball mill grinding with desliming classifiers such as "Dorrs," the most efficient classification results with a dilute overflow. It is also true that the more dilute the overflow the finer the solids contained therein, that differential flotation of lead-zinc ores usually requires finer grinding than common practice for copper ores, and that, ordinarily, to get the most efficient classification and fineness of overflow desired, the pulp density of that overflow is lower than desirable for lead machine feed. The usual practice has been to strike a compromise.

The case cited above has particular application to Sullivan ore milling. The mineral mixture is so intimate that grinding to 90 percent —200 mesh should be practiced for mineral liberation, and hence most efficient concentration. To secure this, classifier overflow density should approximate 25 to 30 percent solids. With an ore of specific gravity such as Sullivan (4.35) desirable pulp density to lead flotation is 45 percent solids.

We are installing the first unit of wnat we believe to be a novel provision to make possible ideal conditions during both fine grinding and flotation operations. The classifier overflow will be of density desirable for classification. This will be sent to Genter vacuum thickeners in which an open weave filter medium will be used. A dirty water filtrate will result but the filter rate will be very high. The filtrate will be returned to the classifier for dilution purposes and the spigot will be controlled at the density desired for lead flotation. This will go to a surge tank and thence to flotation.

2. *Proper Treatment of Middling Products.*—This problem is present in flotation as in former gravity work. It has been our experience that we can return lead middling to the original grind, even to the extent of a high percentage of the total lead circulating, and maintain good results. Not so with zinc middling, particularly if zinc content of feed is high. It is our opinion that the ideal disposal for middling is to separate units for retreatment of middling products, producing therefrom their own concentrate and final tailing products. We consider concentrate products from middling plants can satisfactorily join rough concentrate products from the main circuits as feed to cleaners. (*Continued on page* 690)

Fig. 4—Tadanac (Customs) Concentrator, Trail, British Columbia

CONCENTRATION OF LEAD-SILVER ORE AT THE HECLA MINE, GEM, IDAHO*

Vanners Replaced By Callow Flotation Cells—Individual Motor Drives—Oversize Ore Hand-Sorted—Crude Smelting Approximately One-Half The Amount of Concentrates—Gravity Concentration By Harz Jigs And Tables—Tailings Profitably Retreated

By W. L. ZEIGLER †

THE gravity concentrator of the Hecla Mining Co. was originally constructed in 1888 by the Milwaukee Mining Co., which was operating the Gem of the Mountains mine. It was purchased by the Hecla Mining Co. in 1900, and placed in operation 2 years later. At that time the capacity was only about 200 tons a day, but many additions and changes in equipment have been made so that the present capacity is about 800 tons (Fig. 1). One of the outstanding improvements made was the substitution of Callow flotation cells for vanners, which occurred in 1915. The recent building of a flotation plant for treating jig tailings, and the construction of a modern surface plant at the mine, following the fire of July 13, 1923, have helped the company to maintain its reputation for economical and efficient work.

The lead-silver ore from the Hecla mine at Burke, Idaho, is hoisted from the skip pockets on the various levels and dumped automatically into a reinforced-concrete tipple bin of about 1,000 tons capacity. At this point is an interesting arrangement of bins facilitating the storing of waste and ore from the Star and Hecla mines simultaneously. As desired, a steel chute with a swinging apron, actuated by counterweights and an air lift, passes over the Hecla bin, and runs the material by gravity to either the waste bin or the Star ore bin. This mechanism may be raised or lowered in a short time by the skip tender, and is often switched several times during the shift, depending on the amount of material available in the mine.

From the lower part of the Hecla bin the ore passes through an air-operated gate to a 4 by 8-ft. Sheridan grizzly, driven by a variable-speed motor, which acts as both a feeder and a scalping screen for the 28 by 36-in. Traylor "Bull Dog" Blake-type primary crusher. This crusher is set at about 5-in. opening, which is rather coarse, but at this point it is a decided advantage to hand sorting not to crush the ore too fine. Both the undersize from the grizzly and the crushed ore are taken on a 24-in. conveyor at a 16° incline to the top of the sorting plant, a reinforced concrete and steel structure of sturdy design. The entire surface plant at the mine was destroyed by fire in July, 1923, and was rebuilt in the same year with this type of construction. All machines have individual motor drives, through gear reducers or belts. The normal capacity of the sorting plant is about 140 tons per hr., and enough ore is handled in six days to supply the mill for the week, with Sundays used alternately as repair days and days of rest.

SORTING

Dropping from the main conveyor, the ore is diverted to two separate units by a swinging-wing mechanism. From a converging rail grizzly with 3-in. spacing the oversize slides down a chute over a roll feeder to sorting belts, the undersize passing over a roll feeder to a 4 by 6-ft. vibrating screen with 1¾ by 2½-in. openings. The oversize passes directly to the sorting belt, and forms a cushion on the belt for the large oversize from the grizzly. The undersize falls into a chute and is carried by a short conveyor to a point which will reach the shuttle conveyor, no matter what its position.

Directly in front of the coarse-rock chute, a double line of water sprays washes the oversize on the sorting belts, making the ore more adaptable for hand-sorting. Three men on each side of each belt pick out crude ore and waste, which are dropped into chutes and fall by gravity to their respective bins. Each ore sorter produces about 12 tons of crude ore per 8-hr. shift, and each waste sorter about 25 tons of waste; the balance of the material on each sorting belt is crushed in a gyratory to 1¼ in. All crushed ore joins the screened undersize on a shuttle conveyor and is spread in two mill ore bins of about 3,200 tons total capacity.

The fines washed from the belts by the water sprays are deslimed by two drag classifiers, the sand going to each shuttle conveyor and the slime overflow to a thickener. The dewatered slime is further dried by an Oliver filter, and mixed with the mill feed in the bins.

The crude smelting ore assays about 50 percent lead and 28 oz. silver to the ton, about the same as the concentrate produced by milling. Not only does hand-sorting of this ore give extra capacity for the operations, but it saves transportation charges of 12½ cents per ton on the transfer of the ore from the mine to the mill, saves the difference between the cost of sorting and that of milling, and also the difference in losses in sorting compared with milling. The amount of crude smelting ore obtained is approximately half of the amount of concentrates produced by the mill. All the waste sorted out is practically clean of mineral and is trammed to the mine for filling in the stopes.

Fig. 1—Hecla Mining Co., Gem concentrator, Gem, Idaho

OCCURRENCE OF ORE

The galena in the Hecla ore occurs in large lenses and streaks of various thickness, and is mostly fine-grained and hard, making it an ideal ore for hand-sorting and gravity concentration. The proportion of coarse-grained relatively soft galena is small. Occurring in the fine-grained steel galena are minute inclusions of quartz and spathic iron (siderite) with small quantities of sphalerite. Fortunately, these inclusions are not of a sufficient quantity seriously to impoverish the grade of the crude smelting ore or the coarse jig concentrates. The

* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Mill superintendent, Hecla Mining Co., Gem, Idaho.

gangue as well as the country rock is a highly sheared quartzite with some quartz and siderite. Occurring with the vein is a dark-colored lamprophyric dike of varying thickness, which will be on one side or the other of ore, or sometimes in the center. This dike rock is easily spotted on the sorting belts by the waste sorters, and rarely contains any ore.

Quite a proportion of the quartzite is so intensely sheared that the original structure is obliterated, this feature making the ore a comparatively easy one to crush and grind. In the East orebody, which is of minor importance in the mine, the shearing is not so prominent; consequently the rock does not yield to breaking or grinding so easily as that of the main Hecla vein.

Gravity Concentration

All the crushed milling ore (assaying about 8.5 percent lead, 5 oz. silver, 7 percent iron, 0.8 percent zinc, and 67 percent "insoluble") is drawn from the bins into bottom-dump railroad cars and taken 3 miles to the mill at Gem, Idaho. The railroad handles all the milling ore daily in two trains of seven cars each. Gravity concentration is carried out so far as possible, and is accomplished with Harz jigs and tables, all sizing being done with a double line of trommels, using steel plates punched with round holes in various sizes. The ore is jigged in five sizes: —35+18 mm., —18+12 mm., —12+7 mm., —7+3 mm., +16 mesh, each making its respective concentrate, middling and tailing. The middling is crushed at each stage and returned to the original feed, making the recovery of all galena as coarse as possible.

All material passing through 16-mesh is classified by a 6-spigot Fahrenwald constant-density classifier, and tabled in the various sizes, making a concentrate, middling and tailing. Table middlings are ground to pass 150-mesh, and join the original slime, which is tabled on three Deister slime tables, making a clean concentrate. Middlings from the Deister tables are pumped to a 30-ft Dorr thickener.

The tailings from gravity concentrate are dewatered in a drag classifier and the overflow is pumped to thickeners, the underflow from which joins that from the thickener of direct slime, and is treated by flotation. The flotation tailing goes to waste, and the concentrate is dewatered by the usual methods. The overflow from all the thickeners is pumped to the head of the plant and used again for jig water.

Treatment of Tailings

Formerly, the tailings were loaded in railroad cars to be used for ballast, highway surfacing material, or concrete work, or disposed of by an aerial tramway, which dumped them into another gulch. These tailings average about 1.2 percent lead and 0.8 oz. silver to the ton. Further treatment for the recovery of the valuable metals in them had been investigated several times with results that did not warrant the construction of a re-treatment plant; but early in 1925 experimental work was again started with small tests, and later with a flotation test plant that treated at the rate of about 10 tons per day, which showed that the tailings could be ground and treated by flotation at a profit. It was decided to make the new flotation plant an addition, rather than incorporate it in the old concentrator, the original capacity of which had been increased many times, the present arrangement being by no means ideal. The old mill buildings were of timber and board construction, making them more or less hazardous on account of fire, so all new construction was made fireproof.

The New Plant

Construction work on the new plant was started in the middle of July, 1925, and the plant was placed in operation early in the December following. The building is of concrete and steel construction with hollow tile walls, steel sash and corrugated asbestos roofing. The ball mill floor has for its foundation a cellular reinforced concrete block about 14 ft. deep, extending to cemented river gravel, and the cells filled with tailing to give weight to the block. Overhead, built into the steel frame, is a 5-ton, hand-operated traveling crane. With both ball mills running fully loaded, there is not the slightest trace of vibration in the foundation or building. The flotation floor is of reinforced concrete beam construction and spans Canyon Creek.

Adjustable plunger feeders are arranged under the tailing bin which feed by gravity to a 14-in. elevator, discharging to a short 18-in. conveyor. From the conveyor the tailings are discharged into a dividing hopper, from which point the plant is arranged in three separate units. Each unit consists of a ball mill in closed circuit with a classifier, and an 8-cell flotation machine and has an approximate capacity of 300 tons per 24 hours.

The mills discharge by gravity to the classifiers and are operated at about 65 percent solids. The classifiers are operated at 24 strokes per min., making an average sand return to the mills of about 300 percent of the initial feed. On the overflow weir is arranged a 3-mm. screen to remove wood pulp, the screen being cleaned by rubber scrapers, which take their motion from the arms of the classifier mechanism.

The overflow from the classifiers flows directly to the flotation machines. These are driven, instead of the usual construction, by helical bevel-forged steel gears, which not only reduce vibration and noise, but result in a great saving of power. Ordinarily 3.4 h. p. per cell is required, whereas each of these machines is operating at a total of 19.5 h. p., or about 2.5 h. p. per cell.

Fine grinding is not essential for high recovery of lead and silver in the flotation of the tailing, the degree of coarseness being limited principally by the flotability of the mineral particles. A sample of the final flotation tailing is presented below.

SCREEN TEST AND ANALYSIS OF FLOTATION TAILING

	Weight Percent	Lead Assay Percent
— 28 mesh	Trace	0.1
— 48 mesh	7.5	
—100 mesh	22.5	0.14
—200 mesh	16.5	....
—200 mesh	52.5	0.13
Total sample		0.13

Solids, 42.3 percent.

Reagents used are Barretts No. 4 coal tar creosote and cresylic acid in equal proportions, and a very small amount of xanthate and soda ash. The first cell of each machine is used as a cleaner, producing concentrates which will average about 45 percent lead, with 34 oz. silver per ton.

The concentrate is pumped to the dewatering and filtering equipment in the old mill, and is treated with the concentrate from the primary flotation plant. All middlings from the last seven cells are in closed circuit with the machine, and are picked up by the agitator in the first cell. From the overflow weir in the last cell of the machines the final tailing is discharged into the creek below the flotation floor.

All electrical installation conforms with latest practice. Feeders are lead-covered cables pulled in underground conduit from a central substation, where each division of the concentration plant has individual switches with a recording watt-hour meter. Each unit in the tailing plant has its own switchboard, with an ammeter and recording watt-hour meter, so that the power consumption of each side may be balanced. All small motors are of the bearing type and are controlled by magnetic contactors operated by push buttons from various stations.

Costs

The tailing plant is operating with a wide margin of profit, owing to the low labor, grinding and flotation reagent costs. Profits derived from the recovery of lead and silver in the tailing amounted in about four months to the complete cost of the plant. The Hecla milling costs have always been of the lowest in the district, the average until 1915 being about 35 cents per ton, the increased tonnage taking care of rising costs of material and labor. After 1915, however, prices were so high that the per ton cost rose to an average slightly under 50 cents, although a large tonnage was milled. This cost is still an average for the gravity concentrator with its primary slime flotation.

The cost per ton of milling the old tailings for the first quarter of 1927 was as follows:

Labor	$0.087
Supplies (balls and liners)	.085
Flotation (reagents and supplies)	.013
Electric power	.065
Flotation royalty	.042
Total cost per ton	$0.292

Calculating this cost back against the original mill feed makes a total combined milling cost of about 70 cents per ton.

At this time, of the total concentrates produced, 66 percent is accounted for by the jigs, 14 percent by the tables, and 20 percent by flotation. The coarse concentrate is a very desirable one for the smelters, and, no doubt, will continue to be a reason for using gravity concentration in treatment of Hecla ore.

Manganese ore imports thus far this year have been less than last year. For first half the total had been 359,770 gross tons of 50 percent ore, as contrasted with 410,484 tons for the same period in 1926. How these imports compare with other years are shown in the following table in gross tons:

1923	419,000
1924	505,000
1925	610,130
1926	708,400
To July 1, 1926	410,500
To July 1, 1927	359,800

RECENT FLOTATION PRACTICE AT INSPIRATION, ARIZONA*

Discussion Of Wet Vs. Dry Lime Handling—Lime Emulsion Adopted—Method Of Mixture And Use Described—Alkalinity Control By Titrating Samples—Reagents Discussed—Potassium And Sodium Xanthate Crystal Tests Tabulated—Sodium Hydroxide Compared With Lime Flotation

By GUY H. RUGGLES† and HENRY F. ADAMS‡

IN THIS paper the authors aim to chronicle the experience and salient points brought out in changing flotation reagents at a concentrator which had probably been using a minimum amount of oil at a minimum cost per ton, to a more complicated system requiring a partial chemical control. The original oils were coal tar and pine oil. The new reagents are lime, xanthate and pine oil. It was found that there were no insurmountable difficulties and eventually the cost of the new reagents per ton of ore proved to be very little more than that of the old.

LIME PLANT

When the question of handling lime came up there were two propositions open: (1) to handle the lime dry; (2) to handle it wet in the form of an emulsion. Granting that a dry lime feeder would function properly, delivering lime uniformly, the chief objection was the dust that would be raised when these feeders were being charged or operated, as the only possible location was on a gallery beneath which men were working. With this objection the handling of lime as an emulsion seemed to be the better scheme.

The lime plant which was first installed was for experimental work on one section. This was gradually changed and developed until it was of sufficient size to accommodate 20 sections. The various changes will not be discussed and the following description deals only with the fully developed plant. Crude as it is, and perhaps somewhat expensive to operate, the lime-handling plant has been quite successful. Much has been learned which will pave the way for a better installation in the future.

Burnt lime is received loose in standard gage box cars. This is the product of the kilns and has had no screening or sorting. A grab sample is taken from each car as it is unloaded. An average of the analyses of samples from 44 cars gave the following:

Total CaO Percent	Available CaO Oxide and Hydrate, Percent	MgO Percent	$Fe_2O_3+Al_2O_3$ Percent	Insoluble Percent
88.3	79.2	1.6	1.3	2.2

Although it is not generally done burnt lime of this character should be purchased on the available CaO analysis with penalties for insoluble and magnesia. This would probably be more satisfactory for the consumer than the customary method of purchasing it by the ton. From the car the lime is shoveled into a chute which delivers to a storage house holding about 120 tons. Although built of wood this house has a steel-plate floor and the corrugated iron siding is placed on the inside of the studding, thus minimizing the fire risk.

General View of Grinding and Flotation Floors at the Concentrator of the Inspiration Consolidated Copper Company

Preparation of Lime Emulsion

A batch of 900 lb. of lime is weighed out on the floor of the lime house and elevated, with a bucket elevator, to one of two slaking boxes on top of the emulsion storage tank. Water is added to the lime in the slaking box. The mixture is puddled frequently with hoes until the lumps of lime are well broken. The contents of the box are then sluiced to a stationary, round-hole (1 mm.), punched screen. Practically all of the lime is forced through this screen by hoeing back and forth. Any unslakable material is removed from the screen and carried in buckets to one of the ore belts in any operating section of the concentrator. The laborers at the slaking plant can always handle this small amount of refuse in the above manner; a little lime is probably saved, and the disposal of an otherwise useless product accomplished.

Below the screen is a galvanized iron storage tank of 8,500 gal. capacity and, in washing through the screen, enough water is used to bring the lime emulsion to a consistency of approximately 4 percent burnt lime (as purchased) and 96 percent water. Tables are supplied the lime plant foreman giving the approximate outflow of emulsion in inches per minute for any given number of sections running, so that by taking a gage reading of the tank when a batch of slaked lime is started into the tank and observing the time required for the operation, the correct amount of water can be added to keep the percentage of solids in the emulsion fairly constant.

The emulsion tank is agitated by air passing through perforated pipes. This probably consumes some lime by combination with the carbon dioxide in the air and undoubtedly mechanical agitation would be preferable. Eventually it is intended to replace the slaking by ball mill grinding and to agitate the storage tank mechanically.

Regulation of Strength

A further regulation of the strength of the lime emulsion, and in the last analysis the final one, is obtained by titrating with double normal sulfuric acid. A 50 cc. sample of the emulsion is taken shortly before a batch is washed into the tank. This sample is put in a porcelain mortar, a few drops of phenolphthalein indicator added, and the mixture titrated with the double normal acid to a disappearance of the pink color. During the titration the mixture in the mortar is triturated with the pestle to bring all the large pieces of lime into reaction with the acid. As 30 cc. of double normal sulfuric acid seemed to be the average amount needed this is considered as standard, and should the amount required to neutralize the 50 cc. of emulsion be greater or less than this amount, then in succeeding batches of lime the water per batch is increased or decreased by an arbitrary factor until the standard amount of acid for the titration is again reached. For example, 1 cc. of double normal sulfuric acid is equivalent to 0.056 gm. CaO. Thirty cubic centimeters would be equivalent to 1.68 gm. CaO in 50 cc. of the emulsion, or 3.36 gm. CaO in 100 cc. Assuming that the specific gravity of the emulsion is very close to unity and that the acid constituents of the emulsion are not over 91.1 percent this would calculate an emulsion of 3.69 percent or

* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Mill superintendent, and ‡ test mill foreman, Inspiration Consolidated Copper Co., Inspiration, Ariz.

very near the approximate 4 percent previously stated. This crude method of titrating has proved very useful in regulating the strength of the lime emulsion.

Circulation of Emulsion

For the circulation of the emulsion a 3-in. sand tailings pump with the water seal packed with grease is used. The pump installation is in duplicate. The 3-in. pump discharge extends from the lime plant to the farthest section in the concentrator, about 400 ft., before any emulsion is taken off. The return line passes across the 20 sections, each having a 1-in. pipe branch for the emulsion feed, and the excess emulsion is finally returned to the storage tank. In running this line the entire length of the concentrator before taking off any emulsion there was a definite object in view. It was desired to consume all the pressure which it was necessary to use ahead of the first take-off valve. In this way the first valve and succeeding valves could be run with a wider opening and thus take care of the 1-mm. particles which barely passed the screen in the slaking plant.

A mistake was made at first by placing the 3-in. main below the floor and tapping this with 0.5-in. risers to feed each section. Coarse material soon accumulated in the main, plugging it. An overhead main was immediately installed and since that time has never plugged. While the 3-in. main was put in as straight as possible, nevertheless there are three short radius 90-degree bends with a few turns of lesser angle. A mercury U-tube is connected to the discharge line to indicate pressure and this is usually held at 23 in. of mercury by throttling with the pump discharge valve. Under normal operations, say 15 sections, 110 gal. per min. is pumped. Each section requires about 2.6 gal. per min. which leaves 71 gal. to be returned.

Lime Emulsion Nozzle

With the adoption of the lime emulsion scheme it was soon evident that a regulating valve was needed which always had a circular opening. The result was the lime emulsion nozzle (Fig. 1) designed by F. C. Devereux, formerly a member of the Inspiration concentrator staff. By turning the lower half of the nozzle so as to press the brass washer against the rubber cushion the hole in the cushion is decreased in diameter. The maximum diameter of the opening is 5/16 in. By compression of the rubber cushion the nozzle can be entirely closed. Throughout the entire cycle the cross-section of the opening remains practically circular. In operation it is necessary to have this opening somewhat greater than 1 mm. in diameter as that is the size of the holes in the screen at the slaking boxes. This nozzle is attached at the end of the 1-in. pipes which lead from the 3-in. main. One nozzle is used on each section and discharges into a splitter box which divides the lime equally, one-half going to the scoop box of one ball mill and the balance to the other.

ALKALINITY CONTROL

The control of the alkalinity of the pulp is accomplished by titrating a sample of water removed

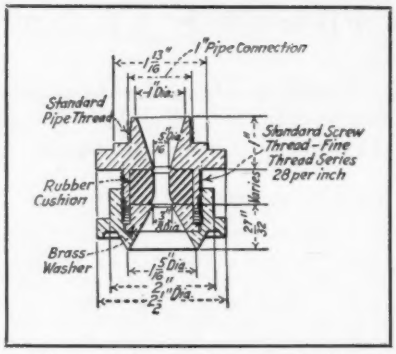


Fig. 1—Lime emulsion nozzle (brass)

from the first cell of the flotation machine hourly, or oftener if desired. The apparatus for obtaining this sample is shown in Fig. 2. This type of filter bag* was first used by B. H. McLeod in connection with another apparatus for determining alkalinity. To obtain a sample the air valve is closed, the vacuum valve opened and a sample of clear water drawn through the filter and into the bottle. When a sufficient amount of water has been obtained, the vacuum valve is closed, the air valve and pinch cock opened, and the water sample forced into the beaker. To clear the apparatus the remaining water is blown out of the bottle and then a little air blown back through the bag. The air valve is finally closed. The sulfuric acid for titrating is of such a strength that when 100 cc. of water are taken each cc. of acid used is equivalent to 0.0001 percent free CaO. The indicator is phenolphthalein. The acid is run in rapidly and no attempt made to split a cubic centimeter. For convenience an alkalinity of 0.0015 percent CaO is spoken of as a "15 alkalinity."

Since the adoption of alkaline circuits by the majority of concentrators many methods of reporting the amount of lime used or the alkaline condition of the pulp have been originated. The effect of the lime is due to the percentage of free CaO present in the water. The pounds used per ton of ore is an economical figure only and has no bearing on the technology. The free alkalinity is reported as grains of CaO per gallon of pulp, as pounds of CaO per ton of ore, as pounds of CaO per ton of water, and as percentage. The basic method of reporting assay values is percentage. The alkalinity determination is an assay of the water for CaO present as a hydrate. For the sake of standardization it would seem advisable that all plants should adopt the percentage method of reporting the free alkalinity.

DIFFICULTIES IN HANDLING XANTHATE

The first xanthate used was a solution of potassium xanthate. This was received in tank cars. The oil-handling system already installed was easily adapted to the handling of this solution. As xanthate solution is a solvent for brass it was necessary to replace many valves having brass parts with all iron valves. It was also necessary to remake most of the pipe joints with a litharge-glycerin cement. The solution was pumped from the tank cars to a storage tank. From there it was again pumped, as needed, to a mixing tank, where it was diluted with water. From this mixing tank the solution was drawn to the mill feeders. The bucket-elevator feeders on each section which had formerly been used for coal tar proved quite satisfactory for xanthate. It was demonstrated in the laboratory that xanthate solution deteriorated when appreciably heated and for that reason all tanks and piping exposed to the sunlight were painted white. Aluminum paint would probably have been better but this was not at hand at the time.

Later the xanthate was purchased in crystalline form in "one time" barrels. For handling this material a wooden mixing box and centrifugal pump in connection with a storage tank were necessary. The procedure was to add the required amount of water to the tank, dump the xanthate into the box, pour a portion of the contents of the tank on the xanthate and pump the solution back to the tank. This procedure was continued until all the xanthate was dissolved. From this point the solution is drawn to the section feeders as before.

PINE OIL

High-grade, steam-distilled pine oil is received in tank cars and pumped to a storage tank. From there it is transferred, as needed, to a smaller tank near the concentrator and then drawn by gravity to the different pine oil feeders.

The greater part of the pine oil is fed into the launder carrying all of the return water from the Dorr thickeners. The feeder used is the same type as used for xanthate. By the time the pine oil reaches the flotation machines it

* B. H. McLeod: A Continuous Alkalinity Indicator for Flotation Pulp. *Eng. & Min. Jnl.* (Dec. 2, 1922), 114, 991.

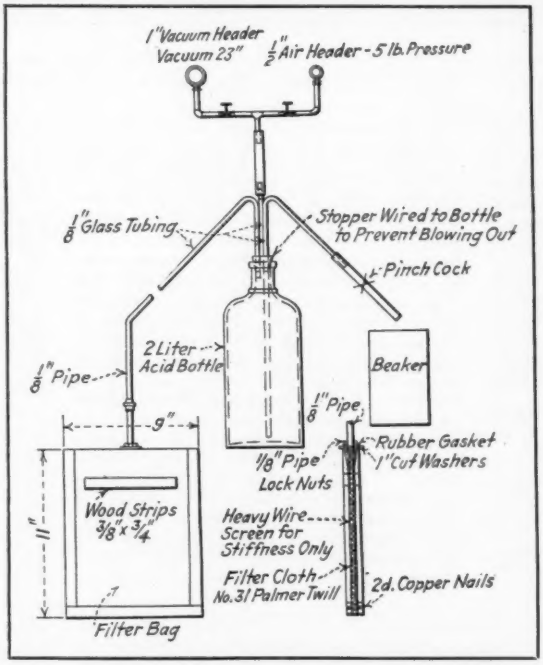


Fig. 2—Apparatus for procuring sample to determine alkalinity of flotation feed

has passed with the water through the pump sump, the triplex pumps, pipe lines, storage tank and ball mills. The object of the remote point of addition is to completely dissolve the soluble part of the pine oil and thoroughly mix the remainder with the water. Adding the pine oil at one point in this manner steadies the frothing conditions. Should any section on account of old flotation blankets or a different ore condition need more pine oil it is added from a drip can to the lime-distributing box between the ball mills.

Test Mill Experiments

After laboratory work had demonstrated the advisability of conducting experiments on a larger scale with the lime-xanthate-pine oil combination of reagents further experimental work was carried on in the test mill. The capacity of this plant was approximately 5 tons an hour for the grinding conditions it was desired to maintain. The flow sheet was similar to that shown in Fig. 3, which represents a section of the concentrator.

A few typical runs made in the test mill are given in Table 1. The component listed as "oxide copper" is the copper present as the silicate. To date no economical process for the flotation of this mineral has been discovered. Although this paper pertains to flotation reagents the assays in the various tabulations are those of the general concentrate and general tailing. The concentrate recovered in tabling lowers the assay of the flotation concentrate and reduces the assay of the flotation tailing. The flotation results and final results are parallel.

Previous experience with reagents somewhat similar, laboratory tests and results at other plants, had all shown that an alkaline circuit was necessary with xanthate. Burnt lime had the advantage of being cheap and promoting the settling of the concentrate and tailing. These advantages seemed to outweigh the chief disadvantage, that of making a large amount of scale. It was thought advisable to determine definitely once and for all if lime was required with xanthate at Inspiration. Periods 25 and 26, Table 1, bring out this point conclusively. Potassium xanthate crystals, of a high grade of purity, were dissolved in water and added at the head of the flotation machine in the quantity shown. Steam-distilled pine oil was introduced at the same point. If lime was used it was added in the dry form, from a slowly moving conveyor belt, to the ball mill scoop box.

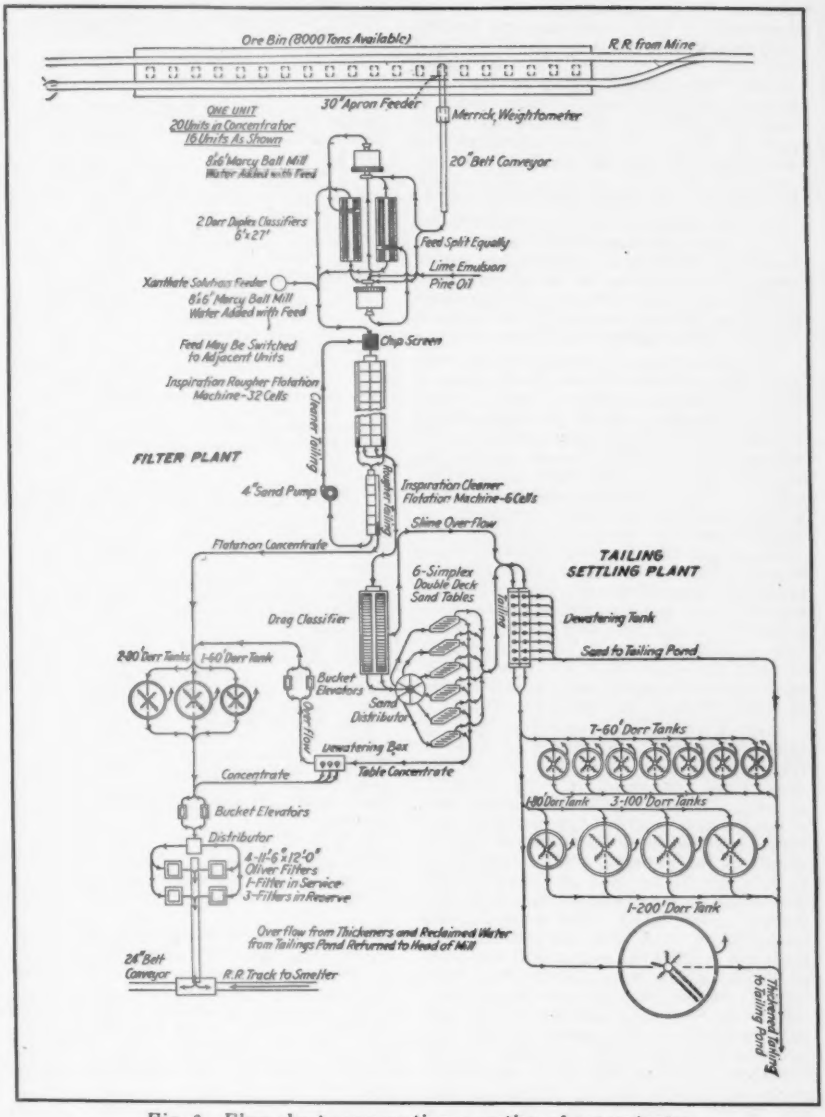


Fig. 3—Flow sheet representing a section of concentrator

As the xanthate is an expensive reagent, the logical step was to reduce the quantity. Period 27 shows that this did no harm; in fact, there was a slight improvement in the sulfide tailing over the runs made in period 26.

If some lime was a benefit would more be better? To answer this question period 28 was run. The alkalinity was increased to 0.0207 percent free CaO in the water of the first flotation cell, where previously 0.0045 percent had been used. There was no improvement in the sulfide tailing; in fact, there was a slight increase, which possibly might have been due to the coarser grinding. The concentrate was raised in grade about 4 percent copper. Subsequent periods indicated that this was due to some condition other than the increased lime, although it is generally supposed that high lime will make a high-grade concentrate.

Tests 29 and 30 were run without returning reclaimed water. This was done to approximate conditions on a single

TABLE 1—TEST MILL EXPERIMENTS

	No Lime	With Lime	Cutting Xanthate	Increasing Lime	Decreasing Lime	Increasing Xanthate
Period No.	25	26	27	28	29	30
Number of days	6	6	6	6	4	6
Feed:						
Total copper, percent	1.121	1.086	1.174	1.228	1.220	1.188
Oxide copper, percent	0.321	0.247	0.246	0.283	0.288	0.313
Sulfide copper, percent	0.800	0.839	0.928	0.945	0.932	0.875
Concentrate:						
Copper, percent	26 799	25.815	28.596	32.741	33.800	33.081
Insoluble, percent	16.37	22.47	18.34	18.27	11.60	12.30
Iron, percent	24.09	21.84	22.07	19.55	21.88	22.08
Tailing:						
Total copper, percent	0.462	0 298	0.282	0.337	0.353	0.362
Oxide copper, percent	0.322	0.247	0.235	0.283	0.288	0.312
Sulfide copper, percent	0.140	0.051	0.047	0.054	0.065	0.050
Ratio of concentration	39.97	32.38	31.74	36.37	38.58	39.61
Total recovery, percent	59.82	73.41	76.74	73.31	71.82	70.30
Sulfide copper, recovery, percent	82.95	94.11	95.10	94.45	93.21	94.43
Flotation feed, percentage on 48 mesh	1.4	2.6	2.4	6.3	3.8	3.1
Reagents:						
Lime, lb. per ton	....	2.78	2.75	5.17	3.77	3.68
Xanthate, lb. per ton	0 247	0.212	0.090	0.070	0.084	0.147
Pine oil, lb. per ton	0.134	0.127	0.131	0.130	0.139	0.120
Alkalinity of first cell:						
Water, CaO, percent	....	0.0045	0.0047	0.0207	0.0050	0.0045
Reclaimed water	Yes	Yes	Yes	Yes	No	No

section of the concentrate where it had been decided to try the xanthate eventually and where there would be no benefit from the reagents in the return water. The sulfide tailing in period 29 seemed too high, and for that reason it was thought that more xanthate was needed. In period 30 the xanthate was increased and the sulfide tailing reduced.

Quantities of Reagents Used in Test Runs

It now seemed as if the quantities for use on the section test (1,000 tons daily) had been determined: Alkalinity, 0.0045 percent free CaO in the flotation water; xanthate, 0.15 lb. per ton of potassium xanthate crystals; pine oil, to make a suitable froth, about 0.14 lb. per ton.

Popular opinion, as it might be termed, has always been of the trend that a flotation reagent added to the ball mill during grinding would be more thoroughly mixed with the pulp and for that reason more effective in the production of low tailings. That there are other effects, adverse to good flotation, when using so-called chemical reagents, is brought out by the series of tests outlined in Table 2. It was definitely proved that if either the T. T. mixture (20 percent thiocarbanilide—80 percent orthotoluidin) or postassium xanthate were added to the ball mill the resulting flotation concentrate would be lower in copper and higher in insoluble than the concentrate produced by adding these same reagents without the ball mill circuit.

With the T. T. mixture four sets of tests were made. The screen analyses of the flotation feed show that there was very little difference in the original grinding. When the T. T. mixture was added to the head of the flotation machine the flotation concentrate had a little over 61 percent solids —200 mesh. If the mixture was put into the ball mill the flotation concentrate had but 40.7 percent of the solids —200 mesh for one set of tests, and 49.0 percent for the other set. With the mixture at the head of flotation the total concentrate was high in copper (34.715 and 36.525 percent) and low in insoluble (13.20 and 11.61 percent). The assay of the concentrate when the T. T. mixture was introduced into the ball mill was what might be termed low in copper (29.389 and 30.833 percent). In one of these sets of tests (periods 8 to 11, third column) the insoluble was high, 16.81 percent. The other run (periods 12 to 15, fourth column) for some unknown reason shows a low insoluble, 12.72 percent.

With similar grinding the addition of potassium xanthate to flotation produced a concentrate having 62.8 percent —200 mesh, whereas with the potassium xanthate added to the ball mill the flotation concentrate was very coarse, only 36.4 percent passing 200 mesh. The difference in the total assay of the concentrate is remarkable; 35.847 percent copper when the xanthate went to flotation and 30.44 percent copper when the xanthate was added to the ball mill; insoluble, 10.94 percent in the former instance, as 22.15 percent in the latter.

The phenomenon was first noted when coarse material appeared on the table handling the flotation tailing, when the reagent was added to the ball mills. At the time the grinding was what was considered standard. Later coarse material commenced to bank in the flotation concentrate launders. The explanation seems to be that the presence of the very powerful flotation reagent in the grinding circuit classifier caused the flotation of middling grains, that needed further grinding, off the classifier and into the flotation feed. Conditions in the flotation machine were not proper for the reflotation of these grains and some passed the flotation machine and appeared on the table.

In none of these tests was any benefit obtained through a low tailing by the addition of the reagent to the ball mill. There was much harm done to the concentrate, and for these reasons it seems safe to state that reagents of the types discussed should always be added without the grading circuit.

TABLE 2—CHARACTER OF CONCENTRATE PRODUCED BY ADDING REAGENTS TO BALL MILL

Points of Addition	T. T. Mixture				Potassium Xanthate	
	To Flotation		To Ball Mill		To Flotation	To Ball Mill
Periods	3 to 7	16 to 20	8 to 11	12 to 15	29 to 31	32
Number of days	31	29	26	36	12	4
Flotation feed:						
+ 48 mesh, percent	3.0	2.8	3.4	5.2	3.6	4.6
+ 65 mesh, percent	11.2	11.2	11.4	12.4	12.2	12.8
+100 mesh, percent	12.6	12.8	12.2	12.2	12.4	11.8
+150 mesh, percent	9.6	7.6	8.0	7.8	5.6	4.8
+200 mesh, percent	8.0	8.6	9.6	8.6	11.6	11.0
—200 mesh, percent	55.6	57.0	55.4	53.8	54.6	55.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Flotation concentrate:						
+ 48 mesh, percent	0.4	0.3	4.3	1.1	0.1	10.5
+ 65 mesh, percent	0.8	1.3	13.5	8.9	0.4	16.2
+100 mesh, percent	9.7	8.7	17.5	16.0	5.7	16.7
+150 mesh, percent	12.0	13.2	11.5	11.7	8.9	7.0
+200 mesh, percent	15.6	15.2	12.5	13.3	22.1	13.2
—200 mesh, percent	61.5	61.3	40.7	49.0	62.8	36.4
Total	100.0	100.0	100.0	100.0	100.0	100.0
Flotation concentrate:						
Copper, percent	34.715	36.525	29.389	30.833	35.847	30.445
Insoluble, percent	13.20	11.61	16.81	12.72	10.94	22.15
Iron, percent	20.12	19.88	21.95	22.43	20.04	18.50

TABLE 3—PILOT SECTION USING XANTHATE LIQUID IN VARYING QUANTITIES

Period No.	4P	10P	12P	13P	16P	17P	18P
Number of days	17	20	17	8	10	9	10
Feed:							
Total copper, percent	1.040	0.996	1.046	1.080	1.049	1.110	1.010
Oxide copper, percent	0.214	0.192	0.165	0.145	0.159	0.152	0.195
Sulfide copper, percent	0.826	0.804	0.881	0.935	0.890	0.958	0.815
Concentrate:							
Copper, percent	31.791	36.505	37.326	36.984	38.542	40.294	35.265
Insoluble, percent	17.06	17.60	16.74	17.44	16.84	14.73	17.94
Iron, percent	20.93	17.89	17.39	17.22	17.55	16.88	18.44
Tailing:							
Total copper, percent	0.244	0.212	0.207	0.179	0.167	0.187	0.208
Oxide copper, percent	0.188	0.172	0.154	0.133	0.131	0.132	0.173
Sulfide copper, percent	0.056	0.040	0.053	0.046	0.036	0.055	0.035
Ratio of concentration	39.63	46.29	44.24	40.85	43.51	43.45	43.71
Total recovery, percent	77.13	79.17	80.66	83.83	84.45	83.54	79.88
Sulfide recovery, percent	93.39	95.13	94.12	95.20	96.05	94.39	95.80
Flotation feed, percentage on 48 mesh	3.2	3.4	4.0	3.2	2.0	2.9	3.2
Reagents:							
Lime, lb. per ton	2.035	1.235	1.322	1.251	1.236	1.237	1.265
Xanthate, lb. per ton	0.291	0.187	0.127	0.088	0.064	0.054	0.254
Pine oil, lb. per ton	0.039	0.124	0.147	0.153	0.147	0.148	0.160
Alkalinity of first cell water, CaO, percent	0.0019	0.0021	0.0022	0.0021	0.0021	0.0022	0.0021

XANTHATE SOLUTION IN CONCENTRATOR

Although the preliminary work had been with potassium xanthate crystals which assayed approximately 90 percent potassium xanthate and cost about 27 cents per lb. f. o. b. the plant, it was learned that the manufacturers had a "mother liquor," which at that time was supposed to contain 50 percent xanthate, and which was proportionately much lower in price when the xanthate content was considered. The first lot of solution cost 9 cents per lb. f. o. b. the plant. The first test on the pilot section (1,000 tons daily capacity) was made with this liquor. As it had been decided to use 0.15 lb. per ton of 90 percent material it was thought best to start the pilot section on about twice the amount, 0.3 lb. per ton, of 50 percent material. To make a more dilute solution, that was easily regulated, varying amounts of water were added to the liquor received, depending on the amount it was desired to feed per ton of ore. This quantity of 0.3 lb. per ton was successively reduced until a minimum of 0.054 lb. per ton was reached. (See Table 3.)

As soon as anything was demonstrated with the pilot section it was followed up on the entire concentrator, which was treating at that time from 15,000 to 17,000 tons daily. The concentrator results are given in Table 4. The periods are comparative except that the period numbers for the pilot section have the suffix P and those for the concentrator the suffix C.

By this time it had been discovered that the previous methods of analysis were faulty and that instead of containing 50 percent potassium xanthate the "mother liquor" carried between 25 and 30 percent. On this account a price reduction was made and the average of the later receipts was 4¾ cents per lb. f. o. b. the plant.

Considering the pilot section results it can not be said that the use of a greater amount of xanthate lowered the tailing, for as the xanthate was reduced the sulfide copper content of the tailing became less. Nevertheless, it was thought that the quantity of xanthate used in period 17P (0.054 lb. per ton, xanthate content 25 to 30 percent) was perhaps too small as the sulfide copper content of the tailing in this period increased over that obtained in period 16P. However, when the xanthate liquor was increased to

TABLE 4—CONCENTRATOR USING XANTHATE LIQUID IN VARYING QUANTITIES

Period No.	10C	12C	13C	16C	17C	18C
Number of days	20	17	8	10	9	10
Feed:						
Total copper, percent	1.011	1.052	1.075	1.054	1.109	1.039
Oxide copper, percent	0.188	0.164	0.140	0.153	0.159	0.193
Sulfide copper, percent	0.823	0.888	0.935	0.901	0.950	0.846
Concentrate:						
Copper, percent	35.563	37.025	35.798	37.775	38.750	35.958
Insoluble, percent	18.49	17.36	17.78	16.20	15.36	17.61
Iron, percent	18.16	17.85	18.19	18.45	18.50	18.69
Tailing:						
Total copper, percent	0.222	0.208	0.181	0.168	0.186	0.215
Oxide copper, percent	0.177	0.159	0.135	0.134	0.133	0.174
Sulfide copper, percent	0.045	0.049	0.046	0.034	0.053	0.041
Ratio of concentration	44.79	43.62	39.83	42.45	41.78	43.38
Total recovery, percent	78.53	80.68	83.59	84.44	83.63	79.78
Sulfide recovery, percent	94.66	94.61	95.21	96.31	94.55	95.26
Flotation feed, percentage on 48 mesh	5.8	5.9	4.6	3.7	4.0	3.4
Reagents:						
Lime, lb. per ton	1.235	1.322	1.251	1.236	1.237	1.265
Xanthate, lb. per ton	0.295	0.193	0.193	0.117	0.105	0.149
Pine oil, lb. per ton	0.116	0.141	0.149	0.147	0.147	0.159
Alkalinity of first cell water, CaO, percent	0.0021	0.0022	0.0021	0.0021	0.0022	0.0021

TABLE 5—PILOT SECTION USING POTASSIUM XANTHATE CRYSTALS IN VARYING AMOUNTS

Period No.	32P	33P	34P	35P	36P
Number of days	5	5	2	7	3
Feed:					
Total copper, percent	0.986	1.004	0.990	1.003	0.967
Oxide copper, percent	0.236	0.218	0.197	0.206	0.237
Sulfide copper, percent	0.750	0.786	0.793	0.797	0.730
Concentrate:					
Copper, percent	36.270	38.492	40.117	42.991	43.607
Insoluble, percent	16.02	15.24	14.63	13.13	14.33
Iron, percent	18 62	17.18	16.80	16.46	16.03
Tailing:					
Total copper, percert	0.262	0.246	0.242	0.243	0.297
Oxide copper, percent	0.214	0.192	0.190	0.196	0.217
Sulfide copper, percent	0.048	0.054	0.052	0.047	0.080
Ratio of concentration	49.73	50.46	53.31	56.25	64.64
Total recovery, percent	73.96	75.98	76.01	76.20	69.76
Sulfide recovery, percent	93.73	93.26	93.57	94.21	89.21
Flotation feed, percentage on 48 mesh	3.7	4.2	3.4	3.1	3.9
Reagents:					
Lime, lb. per ton	1.697	1.654	1.774	1.620	1.569
Xanthate, lb. per ton	0.07	0.05	0.025	0.02	0.01
Pine oil, lb. per ton	0.124	0.119	0.122	0.140	0.140

TABLE 6—PILOT SECTION USING SODIUM XANTHATE CRYSTALS IN VARYING AMOUNTS

Period No.	44P	45P	46P	47P	48P
Number of days	9	10	8	3	6
Feed					
Total copper, percent	0.992	0.989	0.946	0.930	0.945
Oxide copper, percent	0.138	0.202	0.178	0.173	0.193
Sulfide copper, percent	0.854	0.787	0.768	0.757	0.752
Concentrate:					
Copper, percent	35.503	35.336	35.451	38.707	35.220
Insoluble, percent	14.06	14.81	14.20	12.30	14.35
Iron, percent	19.78	20.15	20.08	19.17	19.75
Tailing:					
Total copper, percent	0.183	0.231	0.214	0.240	0.222
Oxide copper, percent	0.133	0.191	0.171	0.170	0.185
Sulfide copper, percent	0.050	0.040	0.043	0.070	0.037
Ratio of concentration	43.66	46.31	48.14	55.75	48.41
Total recovery, percent	81.98	77.15	77.85	74.66	76.99
Sulfide recovery, percent	94.28	95.03	94.52	90.92	95.18
Flotation feed, percentage on +48 mesh	3.0	3.1	4.0	3.4	3.2
Reagents:					
Lime, lb. per ton	1.248	1.297	1.159	1.190	1.234
Xanthate, lb. per ton	0.05	0.03	0.02	0.01	0.02
Pine oil, lb. per ton	0.124	0.124	0.124	0.121	0.141
Alkalinity of first cell water, CaO, percent	0.0015	0.0014	0.0014	0.0014	0.0015

0.254 lb. per ton in period 18P no better results were obtained than in period 16P with 0.064 lb. per ton. Upon studying concentrate assays it seems safe to say that lowering the xanthate will increase the copper assay of the concentrate.

Period for period the concentrator results (Table 4) followed very closely those of the pilot section (Table 3). The increase in tailing in period 17C caused a little worry and it was thought advisable to fix the amount of xanthate liquor used at about 0.15 lb. per ton which, considering the price, the xanthate content and the result of all the periods seemed quite safe.

The authors point to the sulfide tailings made and the concentrates produced during these periods with considerable pride. From sources other than the manufacturers it was intimated that this liquor contained all the refuse, floor washings and doubtful material produced in an xanthate plant.

Potassium Xanthate Crystals

Coincident with the improvement in the manufacture of potassium xanthate crystals, and the improvement in xanthate content the manufacturers were reducing the price. It seemed that there might be a possibility that the crystals were better than the solution. To test this point a series of tests were made on the pilot section. At the same time reductions were made from time to time in the quantity of xanthate. Starting with 0.07 lb. per ton (period 32P, Table 5) the amount of crystals used in each succeeding period was reduced. A good tailing was made with 0.02 lb. xanthate crystals per ton of ore. When the xanthate was still further cut to 0.01 lb. per ton the tailing increased. Recoveries for the whole concentrator, using about 0.15 lb. xanthate liquid per ton, paralleled these tests very closely. The improvement in the grade of concentrate as the xanthate was decreased, with but little change in the tailing, is quite noticeable.

It will be observed that the amount of lime consumed was much higher than customary. Although alkalinities are not given these were at about the usual standard of 0.0020 percent CaO in the water of the first cell. This excess of lime was due to some change in the ore or proportion between the new and old water. The system of alkalinity control in use takes care of such a situation admirably.

As has been mentioned before, the reagent system already installed was ideal for the handling of the xanthate liquids. If crystals were adopted certain changes would have to be made for dissolving the crystals, as well as provision for the storage of barrels of xanthate. Then, too, the concentrator tailing when using the liquid was a little better than the tests with the crystals. It was possible that the crystals might be a little cheaper in cost per ton but the change was not deemed advisable at this time and it was some months before the crystals were finally adopted.

Sodium Xanthate Crystals

It was generally supposed that sodium xanthate was unstable. The manufacturing costs, however, promised to be cheaper, as caustic soda was cheaper than caustic potash. The lower molecular weight of sodium xanthate, 150, indicated a lower consumption for sodium xanthate than the consumption obtained with potassium xanthate which has a molecular weight of 164. This difference amounted to about 8 percent. In running a series of tests with sodium xanthate crystals on the pilot section (Table 6), it was found that excellent recoveries were made when 0.02 lb. per ton was used. As there was no indication of instability and as sodium xanthate crystals eventually proved to be the cheapest product they were finally adopted.

Alkalinity Control

The method of alkalinity control has previously been described. There has been no difficulty in holding the free lime in the water at the head of flotation within a few ten-thousandths of 1 percent. With this excellent regulation it was not difficult to run a series on the pilot section with the lime slightly lower than standard practice at the time and another in which the lime was higher. These periods, 19P and 20P, are shown in Table 7. The low lime, 0.0010 percent CaO in the flotation water produced the better tailing and a lower concentrate, than the high lime, 0.0040 percent CaO in the water. The economical results with the low lime were much better. Lime incrusts the flotation blankets and the water piping and the higher lime would be a little more expensive although the difference between 0.0010 and 0.0040 percent CaO in the water would not amount to much in dollars and cents. With a consistency of 25 percent solids this would amount to 0.23 lb. lime per ton of ore, using 79.2 percent available CaO in the lime as purchased. It would seem better to use the low lime and obtain the lower tailing.

TABLE 7—ALKALINITY

	Low Lime	High Lime	Soda Ash
Period No.	19P	20P	43T
Number of days	18	6	3
Feed:			
Total copper, percent	1.001	1.077	1.010
Oxide copper, percent	0.231	0.180	0.260
Sulfide copper, percent	0.770	0.897	0.750
Concentrate:			
Copper, percent	33.452	35.718	28.567
Insoluble, percent	18.05	16.63	21.40
Iron, percent	19.14	18.98	19.63
Tailing:			
Total copper, percent	0.237	0.227	0.393
Oxide copper, percent	0.197	0.167	0.250
Sulfide copper, percent	0.040	0.060	0.143
Ratio of concentration	43.48	41.75	45.66
Total recovery, percent	76.87	79.43	61.94
Sulfide recovery, percent	94.92	93.47	81.36
Flotation feed:			
Percentage on 48 mesh	3.1	2.0	1.0
Reagents:			
Lime, lb. per ton	.....	.....	.....
Soda, ash lb. per ton	.....	.....	3.27
Xanthate, lb. per ton	0.143	0.154	0.131
Pine oil, lb. per ton	0.164	0.166	0.142
Alkalinity of first cell water, equivalent percentage of CaO	0.0010	0.0040	0.0017

Although lime is the cheapest alkaline reagent there are a number of others in common use and with the hope that some miracle might be wrought soda ash was tried. Enough of this was added to produce the same alkalinity to phenolphthalein as had been obtained with lime. Possibly this was an incorrect procedure as the phenol alkalinity in the presence of a carbonate only indicates one-half of the carbonate present and for that reason the water contained twice the amount of alkali as was used on former tests. The results obtained when using the soda ash were very poor and at the end of 3 days the test was stopped. This has been reported in Table 7 (period 43T). Laboratory work confirmed the larger test made in the test mill and showed that it was impossible under conditions of water and ore at Inspiration to obtain good recoveries when using soda ash as an alkaline reagent, irrespective of the quantity used.

TABLE 8—SODIUM HYDROXIDE COMPARED WITH LIME FLOTATION LABORATORY

	NaOH	Lime
Test No.	9765	9766
Feed:		
Total copper, percent	1.08	1.08
Oxide copper, percent	0.16	0.16
Sulfide copper, percent	0.92	0.92
Concentrate:		
Copper, percent	25.70	26.66
Tailing:		
Total copper, percent	0.25	0.27
Ratio of concentration	30.66	32.58
Total recovery, percent	77.61	75.77
Lime, lb. per ton	.....	1.5
NaOH, lb. per ton	1.6	.....
Xanthate, lb. per ton	0.08	0.08
Pine oil, lb. per ton	0.12	0.12
Alkalinity of water, equivalent percentage of CaO	0.0030	0.0013

Many other alkaline reagents were tried in the laboratory. One of the most successful was sodium hydroxide which gave results equal to those obtained with lime (Table 8). These are laboratory tests and it is not the usual practice to clean concentrate so it is comparatively low in grade.

Summary

It is possible to make certain conclusions from the experiments described. Lime is necessary and the best practice on Inspiration ore, of the character treated during this series of tests, is to use the smallest amount of lime possible which will give a faint alkalinity to phenol in the water of the circuit. While an increase in lime will increase the grade of concentrate it would also increase the sulfide content of the tailing. A hydrate alkalinity is necessary and as lime produces the cheapest hydrate its use naturally follows.

In whatever form xanthate is used this should be added outside of the grinding circuit, preferably at the head of the flotation machine. The proper quantity, for Inspiration ore, is the smallest amount that will consistently make a good tailing. This has been selected as 0.03 lb. per ton of sodium xanthate crystals. A smaller amount than this would produce a higher grade concentrate but would increase the tailing loss in sulfide copper. A larger amount would lower the grade of concentrate and make no improvement in the tailing. Xanthate liquids, containing impurities of manufacture are just as satisfactory as the purer products in crystalline form, providing enough is used to have an equivalent amount of pure xanthate present.

Although little has been said concerning pine oil the practice which has been found most successful is to add the major portion to the return water circuit, and an additional amount, if necessary, to the ball mill circuit, so that a free-flowing froth is obtained.

ORE CONCENTRATION PRACTICE OF CONS. MINING & SMELTING CO.

(*Continued from page* 682)

3. *Indexes of Efficiency.*—It is always desirable to have some key figure that correlates variables and gives an immediate picture of overall results. We use a number of these throughout our different operations. One of these has particular application to lead-zinc-iron ores treated by differential flotation. We conceived and applied it and during recent years its use has spread with us and its honesty is phenomenal. We call this "the three metal recovery sum." It is the sum of the "percentage of total lead recovered in the lead concentrate," plus the "percentage of total zinc recovered in the zinc concentrate," plus the "percentage of total iron recovered in the iron concentrate." You will see that the ideal or perfect "three metal recovery sum" is "300." The closer the approach to this figure the more efficient the metallurgy. It considers grade as well as recovery. If grade of one concentrate is sacrificed to enhance recovery, recovery of one of the other metals pays for it and "the three metal recovery sum" shows it up. By dividing it by three a "percent metallurgical efficiency" figure can be secured.

4. *Use of the Microscope in Differential Flotation.*—The vanning plaque has lost most of its usefulness in recent flotation practice. As a general thing the zinc flotation looks after the "clean-up" of the lead in the final tailing. This is not always so of the zinc, however. The microscope in the mill for use by the millmen is of incalculable value. At the Sullivan Concentrator, the zinc flotation operators are required to report at 1-hr. intervals their estimate of the zinc content of the final tailing. Their average for the shift is checked again with the shift assays the following day. Marvelous skill has been achieved by them, and it is a fact that they can judge final zinc tailing to 0.1 percent zinc. Their monthly average estimate rarely exceeds 0.05 percent zinc difference from control assay.

Acknowledgment

The success of our present practice is due to a great extent to the splendid work of a number of men in the Concentration Department. To this success the following have contributed largely: C. T. Oughtred, assistant superintendent of concentration, who is also in charge of the Sullivan Concentrator; H. W. Poole, flotation engineer, Sullivan Concentrator; S. Gray, superintendent, St. Eugene Concentrator; H. R. Banks, assistant superintendent, Sullivan Concentrator; and R. G. Anderson, superintendent, Tadanac Concentrator.

GEOLOGICAL REPORTS

The rock strata of the Rocky Mountains were traced in recent years across parts of Colorado, Wyoming, and Montana by the late Willis T. Lee, a geologist of the Geological Survey of the Department of the Interior, in order to obtain information of value to those engaged in the recovery of oil and gas in those states. The oil-bearing rocks are penetrated by the drill at considerable depths in the oil fields, but they reach the surface in the mountains, where they make ridges and foothills. The oil-bearing beds and the associated rocks, which are of many ages, ranging from Pennsylvania to Upper Cretaceous, were traced by Mr. Lee for long distances and found to appear again and again in separate mountain uplifts.

Parts of these three states have been geologically examined in former years —some parts carefully, others hurriedly. Some areas were examined many years ago, and the formation names used then have been discarded; in other areas, examined in recent years, modern names are used for the formations. These changes are discussed in a report by Mr. Lee, recently issued, which also contains much new information on the thicknesses, character, and extent of the rock formations. The report is illustrated with diagrams showing graphically the relations of the formations and with numerous photographs of typical exposures of the rocks. It is entitled "Correlation of geological formations between east-central Colorado, central Wyoming, and southern Montana" and has been published as Professional Paper 149 of the Geological Survey. It may be purchased from the Superintendent of Documents, Washington, D. C., for 50 cents.

Bulletin 787 of the Geological Survey, by H. G. Ferguson, geologist, describes the rock formations and structure of the famous Mogollon district, in the mountains of southwestern New Mexico, as well as the mineralogy and geologic features of the ore deposits themselves.

Although with the gradual exhaustion of the more readily discovered ore bodies the production of the district has been falling off in recent years, the present study holds out some hope for new discoveries.

THE FORRESTER CELL INSTALLATION AT THE NEVADA CONSOLIDATED COPPER CO.'S McGILL CONCENTRATOR*

Discussion Of Callow Cell Vs. Forrester Cell—Ratios Of Concentration Compared—Wide Variation In Ores Treated—Tailings Re-treated Profitably

By E. H. MOHR †

AT THE McGill concentrator of the Nevada Consolidated Copper Co., all flotation operations have been carried out in Forrester cells since November, 1926. In respect to cost of operation, the new cell has proved to be superior to the Callow, which it supplanted, and its incorporation in the flow sheet has resulted in a marked improvement in the metallurgy.

Before citing the advantages of the new machine over the old, it should be explained that the Forrester has not only replaced the Callow, but it has made possible the elimination of a number of tables as well. When Callow cells were in use, table concentration preceded flotation. The ball mill pulp was elevated, by means of air lifts, to roughing Wilfley tables situated two floors directly above the flotation floor. On an intermediate floor were additional tables which cleaned the concentrate from those above. The finished table concentrate constituted approximately 60 percent of the total mill production, and contained about 40 percent of the recovered copper. The table tailings were returned to the classifiers, the overflow from which went to the flotation cells and the oversize to the ball mills.

As soon as the Forrester cells were installed, this tabling operation was discontinued. The ball mill pump now discharges into the classifiers direct, without the intermediate tabling. It was impracticable to employ the present flow sheet when Callow cells were in use, for the reason that unless the greater part of the heavy mineral was first removed, it accumulated on the mats and adversely affected the flotation operation. By tabling ahead of flotation, it was practicable to maintain the concentrator at 10 to 20 percent greater capacity (depending upon the pyrite content of the ore) than was possible by flotation alone. This was due to the necessity for finer grinding in the latter case. Even though the table concentrates contained only 6 to 8 percent copper content, the low smelting costs made it advantageous to operate at high mill capacity, at the cost of low grade of product.

Standard Section Equipment

With the old flow sheet, a standard section consisted of four ball mills and classifiers, one air lift, 20 roughing tables, 10 cleaner tables, 12 primary and 12 secondary Callow roughers with a total of 980 sq. ft. of canvas area, 6 Callow cleaners with 184 sq. ft. of canvas, and 44 Wilfley tables which treated the flotation tailing. The concentrating equipment on a standard 4-mill section now consists of 8 primary Forrester roughers in parallel, each 31 ft. 6 in. long, 8 secondary roughers each 10 ft. long, 4 cleaner cells each 16 ft. long, and 44 tables behind flotation.

Undesirable Features of Callow Cell

The principal undesirable features of the Callow cell were:

1. The accumulation of heavy pyrite on the canvas necessitated tabling ahead of flotation in order for high mill capacity to be maintained.

2. It was usually difficult to maintain regularity and uniformity in the flotation operations, because of the plugging of the blankets with a calcareous deposit and with argillaceous putty-like material, and because of the accumulation of oversize on the mats.

Blanket plugging was variable in extent. When milling certain types of ore, blanket renewals were necessary every 2 or 3 days. The trouble was not serious with the greater part of the ores as indicated by the fact that the average blanket life was 150 days. The flotation feed contained 8 percent plus 48-mesh material. In order to prevent the accumulation of oversize on the cell bottom, and to counteract the plugging of mats, frequent punching was necessary. Satisfactory flotation results were therefore dependent upon the close attention of the operator in adjusting the air valves and in frequent punching of the canvas.

Uniformity of Flotation Operation of Forrester

It is obvious that the disadvantageous features of the Callow cell do not apply to the Forrester. Since the installation of the latter, uniformity of flotation operation has been maintained with much less difficulty than before, copper extractions have been just as high as formerly, the ratio of concentration has been raised to approximately 14 into 1 as compared to the former figure of 9.5 into 1, and an appreciable saving has been made possible in maintainance and power costs.

Fig. 1 shows the end elevation of the type of Forrester now in use. All cells are alike except for differences in length, in size of drop-pipes, and in spacing between the drop-pipes. They are situated on the same floor which was formerly occupied by the Callows.

Ratio of Concentration

In the first unit installed there were three 31 ft. 6 in. roughers in parallel, and one 16-ft. cleaner, to one ball mill. The 10-ft. secondary roughers were added later. It has been determined that two strings of primary and secondary roughers are just as effective as three, for treating the 550 tons of ore per ball mill per day. It has also been demonstrated that one string of roughers is insufficient for treating this tonnage. The standard equipment now installed appears to approximate fairly closely the capacity of the former Callow equipment. In other words, 1 ft. (linear) of Forrester cells appears to be ample for treating the same tonnage formerly handled by 3 sq. ft. of Callow canvas area. This ratio may be improved later in favor of the new machine, but that is a matter of relatively small importance because the low cost of Forrester operation justifies using too much cell space rather than risk having too little.

Drop-Pipe Installation

As originally installed, the drop-pipes in all cells were ½-in. dia. and were spaced at 4-in. intervals, which size and spacing appears to be satisfactory in similar installations at other mills. At the Nevada plant, however, these pipes have proved to be too small. In order to produce the necessary intensity of agitation, air is required at the rate of 60 to 75 cu. ft. per min. per ft. (linear) of cell, the (*Continued on page* 698)

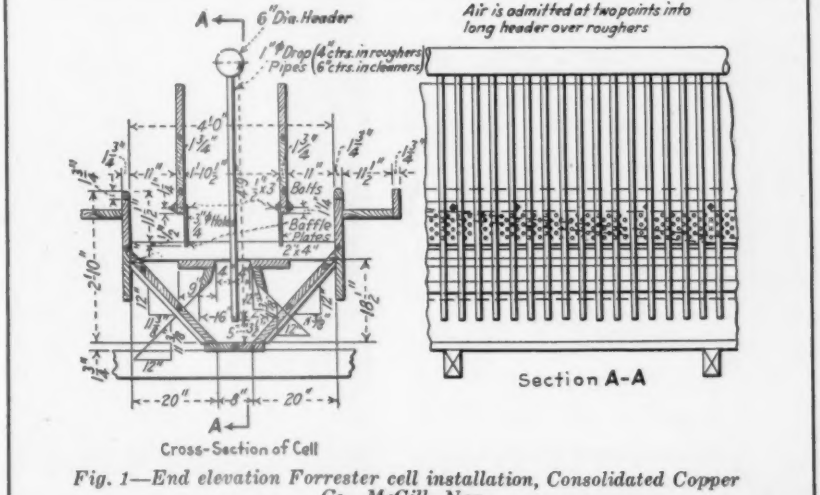


Fig. 1—End elevation Forrester cell installation, Consolidated Copper Co., McGill, Nev.

* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Nevada Consolidated Copper Co., McGill, Nev.

EFFECT OF PREFERENTIAL FLOTATION AT CANANEA MILL AND SMELTER*

Selective Flotation A Field For Intense Research—Ore Formations And Tests Described—Experiments With Mine Water Detailed—Alkalinity And Reagent Control Discussed—Effects On Smelter And Roaster Summarized

By A. T. Tye†

REGARDING the results of preferential flotation at Cananea, Weinig has stated that "The concentrating mill of the Cananea Consolidated Copper Co. at Cananea, Mexico, furnishes an excellent example of modern flotation practice. The complete figures are given because they present so forcibly the advantages of modern selective flotation."[1] L. O. Howard notes that "Perhaps the outstanding example so far published of improvement in results through the use of selective flotation is that at Cananea, Mexico."[2]

The following notes indicate the conditions under which the results were obtained at Cananea; also the effect of preferential flotation at the concentrator and at the smelter.

In the majority of cases the full benefit of selective flotation is not fully realized, as the concentrates are shipped from the mill to smelters owned by other companies. The saving made at a certain concentrator by this method of flotation may be well understood but the saving resulting at the smelter from the results of preferential flotation at the mill is not so apparent, as the data are contained in the smelting records of some other company. Even at the smelter the great gains following preferential flotation may not be noted, as a variety of ores and concentrates from various sources are received, and the difference from the changed concentrator operations of a certain mill may be obscured. As noted by Professor Weinig and Professor Howard, the results obtained at Cananea brought about a veritable metallurgical revolution at the smelter.

There are probably plants at which a better preferential separation is being made than at Cananea. Many ores contain barren iron pyrite which, when depressed, does not carry copper into the tailing. Some concentrators use clean uncontaminated water for milling and in others the ore is ground much finer than at Cananea. All of these items are concerned in perfect separation. The details of preferential flotation at Cananea, therefore, are not presented on account of the perfection of the separation, but because the same company operates the concentrator and smelts the concentrate, and, therefore, as no custom ore is treated, the great results of preferential flotation are clearly indicated both at concentrator and smelter.

Ore at Cananea

At present the ores from Capote, Elisa, Veta and Colorado mines are being treated in the concentrator. When preferential flotation was first studied and laboratory tests made to separate the iron and copper, the only ore treated was from the Capote mine, which has been the chief source of the concentrating ores for several years and has been opened to a depth of 1,600 ft. Therefore, as the caving system of mining is used, some of the levels and stopes have been open for several years and part of the ore has been broken in the stopes for long periods. This mine has at times been on fire, and also has been allowed to fill with water. The heat from the fires and the water from the fire zone have had a tendency to tarnish the sulfides, thus inhibiting to a certain extent the flotation of the minerals. This ore also contains a large amount of soluble salts which leach out when the ore is ground. Fortunately most of the tarnished ore has been passed through, and the ore being treated at present is mainly fresh ore, which floats well, as will be seen in the laboratory tests noted later.

The caving system of mining is not an ideal one if the ore is to be treated by flotation, as the ore tarnishes in the stopes and altered wall rock becomes mixed with the ore, which produces slimes. The slow oxidation of the sulfides also alters the sulfide faces.

A. T. Tye

Dr. G. J. Mitchell, chief geologist of the company, describes the Capote 15 rocks as follows: "The rocks in which the Capote 15 second-class ore occurs are granite-porphyry and alaskite. These rocks are intimately associated, the granite-porphyry being the older. As hosts for ore, they are quantitatively of equal importance. The principal minerals in the granite-porphyry are quartz and orthoclase, both of which show varying degrees of alteration to sericite. What appears in hand specimens as fresh rock is found upon microscopic examination to be strongly affected by sericitization. The sulfides and gangue are intimately associated, occurring as inclusions and as particles adhering to each other. Pyrite with included chalcopyrite and chalcocite is common. In some cases quartz and feldspar contain inclusions or adhering particles of the sulfide minerals. A comparison of the six samples shows that progressively cleaner separation of the mineral is obtained as the degree of grinding is increased." Details of the geology are published elsewhere.[3]

Preliminary Tests

The Capote ore contains over 30 percent iron and sulfur and made such a low-grade concentrate that the cost of smelting was almost prohibitive. In 1920 samples were sent to one of the best equipped flotation laboratories to determine whether the pyrite could be depressed and the copper sulfides floated. The results were very disappointing and for a time it appeared that the selective flotation of this ore could not be accomplished; it was thought that the copper sulfides were included in the pyrite. As a matter of fact, microscopic examination has shown that some of the ore would have to be ground to 400 mesh to liberate some of the copper sulfides from the iron pyrite and from the gangue.

In 1921, during the shutdown, the flotation laboratory was operated as usual to determine better methods of flotation and to find out what would be the better reagents to use when the concentrator was put in operation again. Coal tars from various sources were investigated, and it was found that certain of the tars gave better extractions than others for a given ratio. This investigation was especially directed to obtain a higher ratio in concentration than with sludge acid and sulfuric acid, which had been previously used in the concentrator. Further tests developed that a minimum amount of pine oil also increased the ratio for a given extraction. The use of a certain coal tar with a minimum of pine oil increased the ratio considerably, but even this increased ratio was inconsiderable compared to that developed later with lime.

O. C. Ralston,[4] in 1917, gave a long

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* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Assistant superintendent of concentrator, Cananea Consolidated Copper Co., Cananea, Sonora, Mexico.

[1] A. J. Weinig: The Trend of Flotation. Colorado School of Mines Quarterly (April, 1926), 27.

[2] L. O. Howard: Selective Flotation and Its Relation to Metallurgy. Black Hills Engineer (Jan., 1927), 17.

[3] G. J. Mitchell: Injected Copper Sulphides. Eng. & Min. Jnl. (Jan. 23, 1926); Primary Chalcocite at Cananea. Eng. & Min. Jnl. (May 31, 1924).

[4] O. C. Ralston: Flotation, p. 120, 1917.

list of reagents which either "assisted" or "retarded" the flotation of the various sulfides. Of these reagents, lime proved to be one of the cheapest and most efficient to retard the flotation of pyrite, and it was used successfully at Granby by H. C. Munroe.

In 1921 David Cole called attention to the results being obtained at Granby, but tests run with the Granby reagents did not yield satisfactory results with Cananea ore.

Later tests carried out on Capote ore with coal tar, pine oil and lime gave very successful flotation of the copper sulfides, with the elimination of the greater part of the iron pyrite. These tests were run with fresh ore and with fresh water, with the results shown in Table 1.

It is interesting to note that coal tar, pine oil and lime gave such promising results, as a great many operators are still under the impression that the great success of preferential flotation has been caused by xanthate and T-T mixture.

TABLE 1—FLOTATION TESTS ON CAPOTE ORE, WITH COAL TAR, PINE OIL AND LIME

Test	No. 1	No. 2	No. 3	No. 4
Feed:				
Cu	2.05	2.09	2.08	2.10
Fe	11.20	11.40	11.60	12.20
S	12.50	12.80	12.60	12.20
Oxide	0.01	0.01	0.01	0.01
Concentrate:				
Cu	7.60	10.16	11.88	15.28
Fe	34.00	33.40	31.00	19.60
S	41.00	40.00	38.40	25.20
Insol	16.01	14.80	17.40	35.20
Tailing:				
Cu	0.18	0.18	0.17	0.16
Fe	3.60	6.20	7.80	9.80
S	3.00	6.10	7.60	10.20
Ratio of concentration	3.98	5.24	6.13	7.78
Recovery, percent copper	93.4	93.1	93.2	93.3
Rejection, percent iron	24.0	44.0	56.0	77.0
Pounds of lime per ton	0.0	1.0	2.0	3.0

Two Views of Dam, Cananea Consolidated Copper Company, Cananea, Sonora, Mexico

Water Used in Tests

When the tests were run in 1920, the water from the Capote mine (which is the make-up water at the concentrator) was quite harmless and gave results only slightly less favorable than fresh water. Moreover, it was found that when the alkaline water from one test was used in the next test, satisfactory results were obtained. As it was known that refractory and tarnished ore would be treated when concentrator operations were resumed, tests were also conducted on these ores, which indicated that much less favorable results could be anticipated than with the fresh ore already tested.

The mine water used in flotation tests in 1921 was not particularly injurious but subsequently extensive leaching of old slopes resulted in mine water that was extremely detrimental to flotation. Later on efforts were made to flume the worst water outside the drainage area of the settling dam. The analyses in Table 2 show the water in 1922 and 1924, just before preferential flotation was started in the concentrator, and in 1927. The latter shows the great improvement obtained by segregating the different waters in the mine.

The effect of lime upon the dam water used in the concentrator is shown in Table 3, the water being made just alkaline by the addition of lime in the presence of phenolphthalein.

TABLE 2—ANALYSIS OF CAPOTE MINE WATER
Parts per Million

Date	Ferrous	Ferric	Cu	CaO	SO_3	Alkalinity (CaO)
1922	30	70	17			85 (Acid)
1924	980	1160	42	200	2572	40
1927	60	40	Tr.	110	411	30

On the addition of a small amount of lime to the water, a light yellowish precipitate begins to form, and as more lime is added the color changes to a dark bluish color. When the water shows pink to phenolphthalein, the flocculent precipitate settles out, leaving the clear water as shown in the analysis. The pink manganese precipitate is the last to settle out. The material precipitated from the dam water by the lime gave the following analysis in percent: Fe, 20; S, 5.8; Mn, 11.0; Cu, 1.65; CaO, 3.4; SiO_2, 3.2; Al_2O_3, 3.0.

TABLE 3—DAM WATER ANALYSES
Parts per million

	Ferrous	Ferric	CaO	SO_3	Cu	Alkalinity (CaO)
Dam water	400	200	470	2270	28	Neutral
Same treated and filtered	Tr.	Tr.	420	2106	Tr.	17 (Neutral to phenolphthalein)

Soluble Salts in the Ore

These analyses indicate that the extremely bad mine water can be treated to get rid of the injurious salts and the clear water can be used for flotation, but even when these salts have been eliminated from the mill water there still remains the large amount of the same salts contained in the ore itself. To indicate the amount of these salts, 500 gm. of ore was ground in the pebble-mill with 500 cc. of fresh water. The filtrate analyzed as shown in Table 4.

TABLE 4—FILTRATE ANALYSES
Parts per million

Date	Fe	Cu	CaO	SO_3	Acid
1925.....	400			1193	
1927.....	200	Tr.	520	1824	30

The water entering the primary rod-mills and the water leaving the rod-mills when Capote ore was being treated gave the analyses shown in Table 5, indicating the amount of soluble salts dissolved out of the ore.

Laboratory flotation tests (Table 6) on freshly broken ore from lower levels and on tarnished ore from the upper levels of Capote mine indicate the extreme variation in ore from the same mine, of which it is practically impossible to discover the refractory nature by chemical analysis.

These tests show that assays for oxide copper are useless on tarnished ore and that only flotation indicates the difference in the floatability of the ore. The water-soluble iron is the only indication that the floatability of the tarnished ore is higher than that of the fresh ore.

The Pilot Mill

After operations were started at the concentrator in 1922 it was discovered that the ore had become tarnished in the stopes, although the oxide copper gave almost no indication of the change; therefore it was necessary to install roughing tables to remove as much as possible of the tarnished sulfides, as a large amount would not float. William Wraith again raised the question of preferential flotation in 1923 and tests were run at Cananea, Inspiration and Tooele, using T-T mixture (thiocarbanalide and orthotoluidine), cyanide, lime, coal tar and other reagents. These tests confirmed the tests run with coal tar in 1921 and instructions were given to install a pilot mill to test out the process under actual milling conditions. This pilot mill consisted of one 8 ft. by 28-in. Hardinge ball-mill, one 4 ft. 6 in. by 16-ft. Dorr classifier, one Cole-Bergman flotation rougher, a C-B. cleaner and two 30-ft. tailing thickeners. The primary rod-mill discharge furnished the feed to the pilot mill and the overflow of the tailing thickeners was returned as make-up water to the pilot mill. To eliminate the soluble salts in the water, milk of lime was added to the make-up water from the mines. This was added to the settling tanks, not to the mill feed, and only the clear overflow was returned to the ball-mill and classifier.

This was done to duplicate as far as possible the results of running mine water to the dam and precipitating the salts in transit by the addition of lime. At the same time, tailings entered the thickeners and the coarse sand and slime carried the precipitated salts to the bottom, covered them and discharged them out of the system, just as is being done at the dam at present.

TABLE 5—ROD-MILL WATER ANALYSES
Parts per million

Water	Ferrous	Ferric	CaO	SO_3	Mn	Cu	Alkalinity (CaO)
Rod-mill inlet.....	20	Tr.	1160	1999	Tr.	Tr.	89P : 112 M. O.
Rod-mill outlet.....	560	430	900	5728	104	10	Neutral

P. = phenolphthalein; M. O., methyl orange.

TABLE 6—LABORATORY FLOTATION TESTS

Ore	Percent A. S. Cu	Percent A. S. Fe	Percent W. S. Fe	Percent Tailing, Cu	Flotation Recovery, Percent, Cu
Tarnished	0.02	7.4	0.4	1.43	39.0
Tarnished	0.01	4.8	0.6	1.41	7.6
Fresh	0.07	5.2	0.3	0.17	97.2
Fresh	0.04	5.6	0.2	0.09	95.8

A. S. = acid soluble; W. S., water soluble.

TABLE 7—RESULTS OF TESTS IN PILOT MILL

Feed		Concentrate		Tailing			Recovery percent, Cu	Reagent, lb. per ton	Alkalinity, lb. CaO per ton water
Cu, Percent	Fe, Percent	Cu, Percent	"Insol," Percent	Cu, Percent	Fe, Percent	Ratio of Conc.		T-T	
1.91	17.1	13.5	12.4	0.16	13.0	7.6	92.7	0.61	0.308
1.90	16.6	10.3	11.6	0.19	11.0	5.8	92.0	0.50	0.196
								Z-I	
1.92	15.4	5.3	4.0	0.17	7.0	2.9	94.1	0.39	0.297
1.92	18.0	5.9	9.4	0.15	8.0	3.2	94.5	0.31	0.252
1.88	15.8	6.7	7.0	0.17	8.0	3.8	93.3	0.24	0.246
1.80	14.6	9.1	5.4	0.15	10.0	5.4	93.2	0.18	0.315
1.91	16.0	10.3	5.8	0.17	11.0	5.8	93.6	0.13	0.329
1.89	16.2	11.7	7.2	0.20	12.0	6.8	91.0	0.07	0.364

Tests were run in this pilot mill, using T-T mixture and xanthate and gave excellent results. When the T-T mixture tests were completed, potassium xanthate (Z-I) was used with equally good results (Table 7.)

T-T mixture in large amounts gave the highest ratio with high extraction. With a ratio of concentration of 5.8 into one, for comparison, T-T mixture gave an extraction of 92.0 percent Cu compared to 93.6 percent with xanthate. The simplicity of handling the xanthate, the small amount required, and the low cost were decisive factors in adopting xanthate.

The table of results with xanthate is very informing, as it indicates how xanthate floats the iron pyrite and makes a low ratio when large amounts are used, whereas the iron pyrite is increasingly depressed and the ratio increased when the xanthate is decreased; a good example of the limitation of reagents for preferential flotation. It is well to emphasize this effect of xanthate, as operators are still found who believe that somehow modern preferential flotation has been caused by the use of xanthate, whereas the tests described and others at the Nacozari concentrator proved that coal tar gave as good preferential depression of the iron pyrite as did T-T mixture. However, for entirely different reasons, such as the effect on thickeners, filtering, etc., as well as storage and ease of preparation, no operator would think of going back to coal tar and fuel oil alone, but many use a very small amount of these reagents with the xanthate, to develop a more substantial froth.

The operation of the pilot mill demonstrated that it was impossible to obtain good results with raw water or even with water which contained the gelatinous precipitate caused by the addition of lime. A continuous run, day and night for several days, also proved that the precipitated salts would not build up in the water. Fortunately these tests were run in the pilot mill, because at first the results in the concentrator were extremely disheartening. As the pilot mill had demonstrated that success was possible, the concentrator test was continued until success was achieved.

Mill Operations

In April, 1924, the concentrator was started on a preferential flotation basis. As the dam was full of mine water containing immense amounts of ferrous, ferric and manganese salts, sulfuric acid, etc., it was nearly two months before the water coming back to the concentrator was free from these objectionable salts. The tailings were so high and the results so poor until the dam water was finally conditioned that some of the operators did not recover from the strain for several months.

At present the mill operations are carried on as follows: All mine water going to the dam is treated with milk of lime as it flows down the arroyo past the concentrator. At the same time a small stream of tailings is allowed to mix with the lime water, which buries the precipitated salts. Therefore only clear water is pumped from the dam to the concentrator, alkaline and free from all manganese and iron salts. Lime is fed into the rod-mills by automatic feeders, the amount being regulated by the quantity required to give the desired alkalinity at flotation feed. The lime used is produced locally and costs only $5.50 per ton. It is handled automatically from the time it enters the crushing plant, and gives very close regulation.

Alkalinity and Reagent Control

Titration for the alkalinity of the various waters is made every hour: the treated mine water passing the concentrator is held at about 0.40; the flotation feed at 0.56 and the dam water at 0.056 to 0.11 lb. CaO per ton of water. There is no difficulty in holding the alkalinity

1 Eight crude-ore bins, capacity 3,000 tons.

2 One 8N gyratory Allis-Chalmers crusher.

3 One Cole shaking screen 4½ by 4½ by 1 in. mesh.

4 One Symons 48-in. vertical disk crusher.

5 Six fine-ore bins, capacity 2,400 tons.

6 Two 750- ton rod-mill storage bins.

7 Two 6 by 12 in. C. B. red-mills.

8 Five 8 ft. by 28 in. Hardinge ball-mills.

9 Four C.-B. triplex drag classifiers.

10 Six Inspiration-type rougher sections.

11 Three Inspiration-type cleaner sections.

12 Three Inspiration-type recleaner sections (one in operation).

13 Two 80-ft. Dorr thickeners (one in operation).

14 Four 11 by 12 in. Oliver filters (one in operation).

15 Railroad cars to smelter.

CONCENTRATOR FLOW SHEET

at any determined point although rapid changes in the ore may require a great change of lime delivered at the feeders. Capote ore requires much more lime than the other ores and tarnished Capote ore much more than fresh ore. These titrations safeguard the water supply, since no ferrous, ferric or manganese salts will remain in solution if the water is alkaline to phenolphthalein indicator.

Pine oil is fed in the smallest amounts necessary to give a lively froth. The consumption with the present combination of ores is about 0.18 lb. per ton of ore.

Xanthate is used as a 25 percent solution and is fed as near the head of the flotation cells as possible. G. H. Ruggles, at Inspiration, demonstrated that if xanthate is fed farther back and given a greater time of contact, the same amount of xanthate would float more iron pyrite and coarser sulfide particles, and this was also clearly proved at Cananea in 1924. In May, 1927, the amount of xanthate being used, is about 0.08 lb. per ton, but at times the amount has been as low as 0.06 lb. per ton. Capote, Elisa, Veta and Colorada ores are being treated together and the amount of xanthate required for the best work on each ore is different. With Capote, Colorada and Veta, only 0.03 to 0.06 lb. per ton is needed to give the best ratio; with Elisa the amount may be as high as 0.12 lb. per ton, which gives a high ratio and a better extraction than with the smaller amount used with the other ores. Therefore a compromise amount is used. The results may not be quite as good as though each ore could be treated separately, but this is impracticable under present conditions.

Flotation of the Ore

The overflows from the five classifiers are conducted by inverted siphons to a central distributor in which the xanthate and pine oil is evenly mixed with the flotation feed, so that all flotation sections receive the same feed. These inverted siphons are very convenient, as the vertical pipes run under the floor and conduct the pulp to the central point. They are out of the way and do not block up the mill at the head of the flotation machines as launders would. The vertical depth is 10 ft., the difference of head is 22 in. and the horizontal distance, 40 ft. These pipes do not give trouble in any way. The six flotation sections are of the Inspiration type, containing 12 cells 3 by 4 ft. About 75 percent of the concentrate is taken off the first three cells and goes direct to the filters. The froth from the remaining nine cells is cleaned in a cleaner section of three cells and the concentrate from all the cleaner cells is recleaned in another three-cell machine. It is remarkable how this cleaning and recleaning steps up the grade of the concentrate by dropping insolubles and iron. The tailings from the cleaner and recleaner are returned to the classifiers as make-up water, thus giving an opportunity to free the iron pyrite and copper sulfides from each other by additional grinding of the middlings. The Inspiration machines give excellent results but the lime blinds the blankets very quickly and each requires 6 lb. of air. For this reason Forrester blanketless machines and a MacIntosh machine are being tested against the Inspiration machine.

Grinding and Tonnage

David Cole originally designed the reconstructed concentrator for a tonnage of 1,000 tons per day, or a maximum of 1,200 tons. This tonnage has gradually been built up so that by March, 1927, the tonnage treated, instead of being only 36,000 tons per month, was actually 53,330 tons. This was accomplished practically without any extra machinery. The rod-mills are loaded with 42,000 lbs. of 3¼-in. rods; the Hardinge ball-mills are loaded with 3-in. Monterrey balls as far as it is safe for the motors, and the pilot mill has been incorporated as an integral part of the concentrator and treats 300 tons or more per day of the rod-mill discharge. The two rod-mills each grind 900 tons per day from 1½ in. to 1 percent on 8 mesh. The increased tonnage greatly decreased the cost of milling, which was 83 cents per ton in 1923 with a combined flow-sheet of gravity and bulk flotation (Fig. 1) and only 73 cents in March, 1927. The tonnage has also probably increased because of the higher percent of solids carried in the classifiers. In 1925, for instance, the solids were held at 13 percent to give a preferential grinding to the sulfides as far as possible. At present the solids of the classifier overflows are about 19 percent. It is interesting to compare the screen analysis of the flotation feed and concentrates at 13 percent solids classifier overflow in 1925 with the concentrate produced with 19 percent solids in March, 1927 (see Table 8).

TABLE 8—SCREEN ANALYSIS

Mesh	Flotation Feed 1925	Flotation Feed 1927	Concentrate 1925	Concentrate 1927
On No. 48	4.4	3.6	1.4	3.4
On No. 65	11.8	9.0	7.0	10.4
On No. 100	11.4	13.0	11.0	19.4
On No. 150	11.2	7.0	12.4	9.8
On No. 200	9.4	5.0	10.8	9.4
Through No. 200	51.8	62.4	57.4	47.6
Solids	13.0	19.0	13.0	19.0

Laboratory Tests

The ore received each day from each mine is sampled in separate lots and at times, when the ore is bad, each lot of each ore is tested daily to determine which ore is causing trouble. The tests of Table 9 give the flotation characteristics of the ores treated in April, 1927.

TABLE 9—FLOTATION CHARACTERISTICS OF ORES TREATED AT CANANEA, APRIL, 1927

Ore	Colorada	Capote	Elisa	Veta
Heads:				
Cu percent	2.10	1.81	2.75	2.59
Fe percent	6.68	15.17	16.40	7.98
Concentrate:				
Cu percent	25.38	16.68	25.54	25.26
Fe percent	26.20	31.00	24.80	19.80
S percent	32.80	37.00	30.80	31.30
Insoluble percent	13.00	10.00	5.40	11.00
Tailing:				
Cu percent	0.13	0.19	0.17	0.24
Fe percent	4.00	11.40	12.60	4.00
S percent	3.40	11.80	3.60	2.60
Ratio of concentration	12.81	10.18	9.83	10.69
Extraction, copper percent	93.87	90.56	94.49	91.26
Rejection, iron percent	69.50	80.10	84.70	76.80
Xanthate, lb. per ton	0 03	0.03	0.11	0.06
Lime, lb. per ton	8.6	10.8	9.7	8.6

Résumé of Milling Conditions

With fresh water and fresh ore and only one kind of ore to treat, much better results than those at Cananea would be obtained at other concentrators. What has been attempted is to show that even with bad water, tarnished ore, coarse grinding and a varying mixture of ores, fairly good results have been attained. During this period the tonnage has been increased from the estimated tonnage of 36,000 tons to 53,230 tons per month. Since the system has been established, the method of control has been simple, but in the beginning the conditions were difficult. Mexican operators are used throughout the mill, the only foreigner on shift being the shift boss.

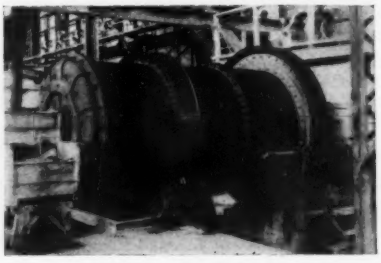
The bad water from the mine is treated with milk of lime on its way to the dam. A small amount of tailings is also added to cover up the gelatinous precipitate. Any fresh water added is sent to the dam and not added at the mill. Lime is added at the rod-mill to precipitate the soluble salts in the ore. Xanthate is added as near the flotation cell as possible in order not to float more iron pyrite than necessary. Pine oil is used in the smallest possible amount as the limitation of the flotation reagents also helps to drop the iron. A clean concentrate is taken off the first three cells of the Inspiration machine and the remainder of the rougher concentrate is cleaned and recleaned, which drops more iron pyrite and insoluble. The results for six months in 1925 and in 1926 with preferential flotation, for comparison with 1923 when roughing and finishing tables and bulk flotation were in use, are shown in Table 9.

RESULT OF PREFERENTIAL FLOTATION AT THE CONCENTRATOR

When the roughing tables operated in 1923 were abandoned, all the coarse iron pyrite formerly removed by the tables had to be ground to flotation size, which caused an increased power consumption of 2 kw.-hr. per ton. Recently, by increasing the tonnage, this has been reduced to a total of 16.6 kw.-hr. per ton. The cost of repairs has been slightly reduced by using an alkaline circuit instead of the acid mine water used in 1923. Other economies from eliminating roughing tables and the finishing tables have more than compensated for the extra grinding and the total costs have remained practically the same, until the first part of 1927, when, with increased tonnage, the total cost has decreased to 72 cents and the repair cost to 9 cents.

In 1923, with a combined gravity and bulk flotation flowsheet, the grade of concentrate was only 4.38 percent copper. With preferential flotation this has increased to over 17 percent copper. The tailing has decreased from 0.29 percent copper to 0.18 percent. The copper recovery, instead of decreasing, as might be expected, has increased from 87.4 percent to 91.5 percent. The silver recovery has also increased, from 88 to 93 percent, and the gold recovery has slightly decreased. Moisture in the filter cake has been reduced to 9.2 percent where formerly in 1923 the concentrate contained 11.4 percent and the "Insol" in the concentrate has been reduced from 15.2 to 7.3 percent.

The ratio of concentration shows the most radical and greatest economic result. This has increased from 2.57 in 1923, to about 10.0 into one with preferential flotation. On the present basis of 1,730 dry tons treated per day, by the 1923 flowsheet 673 tons of concentrate would have to be smelted per day; by preferential flotation, only 173 tons would have to be smelted. The saving at other concentrators can be calculated easily, since the cost of smelting 500 tons of concentrate per day at the local rate would be saved. The cost of transportation and handling 500 tons per day of concentrate would be saved. This large tonnage of barren material would also make a very large amount of slag in the smelter, all of which would have carried off copper in the slag. Therefore the smelter now allows the concentrator an extraction on the concentrates smelted of 97 percent, compared to 91 percent in 1923, which decreases the cost per pound of copper on ore treated in the concentrator. When only Capote ore was treated, 83 percent of the iron was depressed, or 93 percent of the possible iron pyrite present. With a varied mixture of ores, the iron rejection is less than 80 percent.



6'x12' Rod Mill

TABLE 9—COMPARISON OF RESULTS FROM COMBINED FLOWSHEET WITH RESULTS FROM PREFERENTIAL FLOTATION

Flowsheet	Combined	Preferential Flotation	Preferential Flotation
Year	1923	1925	1926
Six months period	Last Half	Last Half	First Half
Cost of concentrating, operation	62 c.	65 c.	60 c.
Cost of concentrating, repairs	16 c.	15 c.	13 c.
Cost of concentrating, total	83 c.	90 c.	81 c.
Dry tons concentrated	252,120	274,928	273,987
Ratio of concentration	2.57	10.18	9.61
Copper recovery	87.40	91.17	91.73
Silver recovery	88.21	90.18	93.72
Gold recovery	95.80	88.82	90.75
Kw.-hr. per ton	15.8	18.2	18.2
Pine oil, lb. per ton	0.61	0.22	0.23
Xanthate, lb. per ton	.....	0.09	0.10
Lime, lb. per ton (total)	.....	11.18	10.70
Cost of flotation reagents	9.5 c.	7.4 c.	6.9 c.
Copper in ore, percent	1.95	1.91	1.98
Iron in ore, percent	16.70	15.70	15.90
Copper in concentrate, percent	4.38	17.69	17.47
Copper in tailing, percent	0.29	0.17	0.18
Iron in tailing, percent	5.2	12.1	13.0
"Insol" in concentrate, percent	15.2	7.3	7.3
Moisture, in concentrate, percent	11.4	9.1	9.2
Rods and balls, cost per ton ore	7.9	6.5	6.1
Tons copper produced on concentrate	4,286	4,775	4,978

TABLE 10—TREATMENT, PRODUCTION AND LOSSES; FIRST HALF OF 1926

	Dry tons	Copper Percent	Copper Tons	Silver Assay	Silver Oz.	Gold Assay	Gold Oz.	Total percent treated
Treated								
Capote 15	207,336	1.68	3,488	0.29	59,554	0.002	414	75.67
Elisa	48,629	2.61	1,298	1.81	88,180	0.003	137	17.75
Veta	18,024	3.55	640	0.14	2,564	0.002	39	6.58
Total treated	273,989	1.98	5,427	0.55	150,298	0.22	590	100.0
Concentrate Produced								
From Capote 15	21,568	14.84	3,200	2.59	55,765	0.017	376	Calculated
From Elisa	5,057	23.59	1,193	16.35	82,688	0.025	124	Calculated
From Veta	1,870	31.28	584	1.28	2,400	0.019	35	Calculated
Totals	28,496	17.47	4,978	4.94	140,864	0.019	536	
Losses								
Tailing	245,493	0.18	442	0.06	15,064	Tr	54	
Unaccountable	.....	....	6	....	5,629	.....	..	
Total	245,493	0.18	448	0.04	9,434	Tr	54	

Percent Recovery			Ratio of concentration
Copper	Silver	Gold	
91.73	93.72	90.75	9.61

Analyses

	Percent Cu	Oz. Ag	Oz. Au	Percent SiO_2	Percent Al_2O_3	Percent Fe	Percent CaO	Percent S
Capote 15	1.68	0.29	0.002	44.0	11.1	16.0	0.3	14.5
Elisa	2.61	1.81	0.003	30.0	5.6	18.9	14.4	8.1
Veta	3.55	0.14	0.002	67.8	5.0	6.7	0.2	5.8
Concentrate	17.47	4.94	0.019	4.7	2.6	30.4	0.3	37.5
Tailing	0.18	0.04	Tr	46.8	11.1	13.0	3.5	10.6

Result of Preferential Flotation at the Smelter

Blast Furnaces Shut-down

When the combined gravity and bulk flotation flowsheet was in operation in 1923, the tonnage of concentrate was so great that part of it went to the blast furnaces and the remainder to the roasters. From 252,020 dry tons treated in the concentrator during the last half of 1923, 97,914 tons of concentrate was produced and smelted. When preferential flotation was introduced with a ratio of 10 into 1, only 25,202 tons would require smelting for the same tonnage concentrated; leaving an unused capacity at the smelter of 72,712 tons per six months, or 145,424 tons per year. Manifestly, a large part of the smelter was thrown out of commission, and, as the concentrate was very fine, a large percentage passing 200 mesh, it was not suitable for blast-furnace work; the logical place to treat such material was in the roasters and reverberatory or in the reverberatories alone. Another reason for preference of treatment of the concentrate in the reverberatories was the lower cost of smelting, on account of the steam generated from the reverberatory gases in the waste-heat boilers. Therefore the more uneconomical blast furnaces were shut down, which eliminated also the large stack loss.

In the second half of 1923, the tonnage of concentrate smelted was 97,914 tons, which assayed 36.0 percent Fe, 37.4 percent S, and 15.2 percent "insoluble." For the second half of 1925, with preferential flotation (assuming the same tonnage treated in 1923), there would be 25,202 tons of concentrate, which assayed 30.2 percent Fe, 36.3 percent S, and 7.3 percent "insoluble." Table 11 gives the tons of Fe, S and "insoluble" that would have to be smelted for the same tonnage concentrated with the 1923 and 1925 ratios.

Roasters Shut-down

Since 54,942 tons of sulfur and 55,276 tons of iron, which formerly went to the smelter, were dropped in the concentrator tailings, the preferential flotation at the concentrator automatically dispensed with a roasting capacity of 54,942 tons of sulfur, was completely eliminated by the concentrator. If this amount of sulfur in iron pyrite had been roasted, only 72.88 percent would have been volatilized, as over 8 percent sulfur remained in the calcines.

Preferential flotation at the concentrator, therefore, more efficiently performed the work of the roasters, as 54,942 tons of sulfur was completely discharged outside of the roaster system. This made it possible to shut down the roasters. As the roaster stack loss was high, this loss was partly eliminated when the concentrate was sent to the reverberatories without roasting. For a time, the moisture in the concentrate was removed in the roasters, but even this was found to be unnecessary and actually detrimental, on account of the resulting dusting of the reverberatories. A. D. Wilkinson, smelter superintendent, finally fed the undried concentrate with beneficial results, from the Messiter spreading beds.[5]

Aside from the saving of the cost of operating the roasters, and the reduction of the high stack loss, there was a great saving of copper and silver. If the 55,276 tons of Fe, 54,942 tons of S, and the 26,086 tons of "insoluble" per year had not been sent into the concentrator tailings launder, it would have been necessary to smelt the material, and this would carry off in the slag a large amount of copper and silver. By eliminating the roasting of the concentrate, the handling and dust losses from fine hot calcines were cut out of the system.

The following from The Mines Handbook[6] is significant when it is recalled that preferential flotation was put into effective operation during the latter half of 1924.

Year	Net income before depl.
1922	$1,459,646*
1923	155,932*
1924	56,122
1925	589,952
1926	584,458

* Deficit.

Concentrator, Cananea Consolidated Copper Company

TABLE 12—GENERAL EFFECT OF SMELTER

	Last half 1923	First half 1926
Blast Furnaces		
Average number operating	4	0
Slag, percent copper	0.38	
Stack loss, percent	1.60	
Grade of matte, percent copper	39.94	
Roasters		
Average number operating	9	
Stack losses	1.85	
Calcine	Dust loss	
Reverberatories		
Average number operating	2	2
Average tons per furnace day	433	276
Stack loss, percent	1.04	1.09
Slag, percent copper	0.29	0.27
Grade of matte, percent copper	18.67	20.30
Converters		
Blast furnace matte, percent copper	39.84	
Reverberatory matte, percent copper	18.67	20.30
Stack loss, percent	1.18	0.90

Extraction by smelter	First half 1924 Percent	Last half 1926 Percent
Smelter extraction on concentrates	92.19	96.85
Smelter extraction on new smelting ores	86.06	93.68
Smelter from all new smelting material	88.52	95.60

Résumé of Effect in Smelter[7]

Prior to the adoption of preferential flotation, the reduction division operated four blast furnaces, two reverberatories, eight roasters, and from two to four converters.

The reverberatory charge consisted of:

	Percent
Calcines (made up of concentrates and high-sulfur ores)	72
New material (oxidized and low-sulfur ores)	16
Blast-furnace dust	12

The beneficial effects of preferential flotation were immediately evident, by reason of a large reduction in the tonnage of concentrates, an increase in their copper content from 4.5 to 17 percent, and a marked change in the physical characteristics. The colloidal content was reduced; the insoluble was reduced about 50 percent; the moisture content in practically the same proportion; the concentrates could be handled easily through the chutes and on the conveyor belts, causing but little, if any, more spill than fine ores.

The daily tonnage of concentrates having been reduced, it became necessary to crush a portion of the coarse material formerly handled by the blast furnaces, in order to give adequate tonnage to the reverberatories. The necessary machinery was installed as an added unit to the old crushing and screening plant, 95 percent of all material crushed passing through ½-in. mesh.

Shortly afterwards the blast furnaces were shut down, leaving but six roasters,

TABLE 11—NUMBER OF TONS SMELTED WITH TWO RATIOS

	Last half 1923	Last half 1925	Decrease in tons smelted	
			Per six months	Per year
Tons concentrate	97,914	25,202		
Tons Fe	35,249	7,611	27,638	55,276
Tons S	36,619	9,148	27,471	54,942
"Insoluble"	14,882	1,839	13,043	26,086
Total six months	86,750	18,598	68,152	
Total year	173,500	37,196		136,304

[5] A. D. Wilkinson: Cananea Smelter Improves Reverberatory Practice. Eng. & Min. Jnl. (Sept. 25, 1926).

[6] The Mines Handbook (1926) 17, 1966.

[7] Private communication from J. Salisbury, acting superintendent of smelter.

one reverberatory, and two converters in operation. The Reduction Division was now receiving a much higher grade of concentrate, but the metallurgical losses through the roasters became a serious problem.

The roaster plant was not equipped with a positive dust-collecting system, having only a dust chamber large enough to secure a low velocity of the gas flow. Though adequate for comparatively coarse low-grade ores, this was inadequate for the collection of dust from the preferential flotation concentrates. The low sulfur content of the roaster feed made it possible to force the tonnage through three roasters instead of six, but the stack losses continued high.

Smelting the entire charge without roasting or drying was found to reduce the capacity of the reverberatory furnace about 50 percent, but the results were so satisfactory that another reverberatory was started and the roaster-plant operation was discontinued.

While the gross ratio per barrel of oil to dry ton of charge was much higher than under the old system, the waste-heat boiler plant was developing about two-thirds of all the power used, and the oil consumption was materially decreased under the direct-fired boilers.

The copper recovery was raised by 5.70 percent, the silver by 4.25 percent, and the cost of smelting a pound of copper was reduced.

FORRESTER CELL INSTALLATION AT NEVADA CONSOLIDATED

(*Continued from page* 691)

volume varying with different types of ores. When spaced at 4-in. intervals, the ½-in. pipes are too small or too few in number to carry this quantity of 20 to 25 cu. ft. per min. per pipe, without excessive pressure loss due to friction. With the present blower equipment, this condition is not serious, because 2½-lb. air is delivered, which pressure is sufficient to force the large volume through the drop-pipes. With the blowers ultimately to be installed, air will be delivered at 1½ lb. pressure, and larger pipes will be required.

It has been determined that ¾-in. pipes will be large enough to meet this requirement. However, 1-in. pipes will be installed, primarily because a sufficient quantity of that size has been salvaged and is available at low cost. Another reason for its selection is because the pipes accumulate a calcareous deposit at the discharge end, which reduces the size of the orifice. The larger pipe will require cleaning at less frequent intervals.

The cleaner cells are now equipped with 1-in. pipes spaced 6 in. apart. The ½-in. pipes originally installed in the roughers, will be replaced by the 1-in. size, but the spacing between pipes will be maintained at 4 in. Local experience has indicated that variations in size and spacing of the drop-pipes, between the limits herein reported, will not affect the actual volume of air consumed. The saving in power that results from using large pipes instead of small ones, is effected because of reduction of friction losses—not because of any reduction in the quantity of air required to produce a given result in the flotation cell.

Air

The volume of air required for operating the Forrester cells has been approximately 60 percent greater than was used for the Callows. The power required for supplying that air to the new machines is appreciably less than for the old, because 1½ lb. pressure is now ample, whereas it was 5½ lb. formerly. At the time of this writing, the plant is operating on 2½-lb. air delivered by blowing equipment designed for 6 lb., and the blower efficiency is necessarily low. It is estimated that with the ultimate 1½-lb. blowing machinery now in course of installation, power consumption will not exceed 2.6 k. w.-hr. per ton of ore, compared to 4.4 k. w.-hr. with the Callows.

No experiments have yet been conducted with cells of design different from those now in use. It is reasonable to expect that changes in construction will be evolved which will make the cell more efficient than the present type, both mechanically and metallurgically, but the margin for saving in operating cost and for improvement in metallurgical performance, is obviously small.

Range of Ores Treated

The ores treated at the McGill concentrator vary over a wide range with respect to their pyrite, chalcocite and chalcopyrite content, and with respect to their amenability to selective flotation. With the present flow sheet, percentage pyrite rejection is variable, being high on some ores and low on others; with the old flow sheet, pyrite rejection was uniformly low. The flotation concentrate produced in the Forrester cells is lower in "insoluble" content than was that produced in the Callows, because it was necessary to operate the latter at a rapid rate in order to counteract the tendency of the blankets to clog. The net result of eliminating the primary tables and of recovering most of the copper by semi-selective flotation with the new type of cell, has been to increase the average ratio of concentration up to 14 into 1, as compared to 9.5 into 1 with the old flow sheet. Though this improvement can not be credited to the Forrester cell alone, the latter has made possible the change in flow sheet which resulted in that improvement.

There has been no change in kind or quantity of flotation agents. The pine oil-xanthate-lime combination has been employed since September, 1924.

Milling Costs Savings

Savings in milling costs made possible by the adoption of the new flotation machine and the altered flow-sheet, have been as follows:

	Cents Per Ton Ore	
Blanket renewals	1.412	
Power for flotation air, 1.8 k. w.-hr. at 0.8 c.	1.440	
Saving in flotation cell operation		2.852
Air lift operation and maintainance	0.934	
Primary table operation	1.001	
Total saving		4.787

Scavenger Cells

Before the tailings are rejected as waste, they are subjected to a scavenging flotation treatment. The equipment for this purpose, which handles the tailings from 14,500 tons of ore per day, consists of 24 18-ft. Forrester roughers in parallel, and three 16-ft. cleaners, also in parallel. The copper recovered by these scavengers varies in quantity between 1,500 and 3,000 lb. per day, and the concentrate varies between 6 and 12 percent in copper content. Even though the amount of copper extracted by these scavengers is small, it is sufficient to justify their operation, for the only item of operating cost is that of air. The attention required is negligible and involves no extra expense.

Summary

1. Forrester cells have been substituted for Callows in the approximate proportion of 1 ft. (linear) of the former to 3 sq. ft. of canvas area in the latter.
2. Due to the elimination of blankets and to the use of low pressure air, the new type of cell is more economically operated than the one which it supplanted.
3. Since the change was made, uniformity of flotation operation has been maintained with much less difficulty than before.
4. With the installation of the Forrester cell, it was possible to make a change in the flow sheet which it was impracticable to make when the Callow cell was employed. This change consisted of eliminating table concentration ahead of flotation.
5. The change in flotation equipment and in flow sheet has resulted in (a) a decrease in the concentrate tonnage by approximately 30 percent without any decrease in extraction, and (b) a reduction in mill operating cost of nearly 5 cents per ton of ore.

PLACER MINING IN IDAHO

Placer operations in southern Idaho are undergoing a notable increase during the current year, according to Ravenel Macbeth, secretary of the Idaho Mining Association. The La Trinidad company, of Las Vegas, N. Mex., has equipped its placer property in the Black Warrior district of Elmore County, and M. T. Rowland and associates of Nampa have the machinery to install a gold dredge at the Kempner ranch on Crooked River, in Boise County.

"The La Trinidad in 1926," said Mr. Macbeth, "equipped its Black Warrior placer at a cost of over $50,000. Equipment was freighted into Atlanta and then packed about 16 miles to the property. At present Elmore County and the company are building a wagon road to the district.

"The total cost of the gold dredge at the Kempner ranch on Crooked River will be under contract of $65,000 to Mr. Rowland and associates, when constructed and ready for operation. The dredge is a 3-foot bucket sluice-box type, and will handle 1,200 to 1,500 cubic yards of gravel daily. Two 60-horsepower semi-marine type Diesel engines will furnish the power for the plant. The contractors are a well-known San Francisco concern. This plant should be operating within 60 days.

"Boise County mining is very active. The Iowa and Gold Hill at Quartzburg is being unwatered by the Talache Mines, Inc., of Talache, in Bonner County, for the purpose of making an examination of the property."

FLOTATION PRACTICE IN COEUR D'ALENE DISTRICT, IDAHO*

A Valuable Description Of Varying Practices In A Famous District—Diverse Ores Listed—Classifier And Ball Mill Efficiencies Compared—Flotation Equipment, Reagents And Oils Used—Grinding Costs Constitute Individual Plant Problems

By A. W. FAHRENWALD †

FLOTATION practice in Idaho is now about 13 years old. The advance has been steady during these 13 years. The operators have been alert to take advantage of the newest developments and they have themselves made a constant effort to improve their work. The metallurgical improvements are due to the development of (1) better equipment, (2) better reagents, and (3) better understanding and control of the process. During the 8 years which the writer has been in this district, there has been continuous experimentation by several companies to improve the ore dressing by flotation methods. Gravity concentration has fought hard to hold its place, and although it is true that gravity processes have been improved during this period, nevertheless, in several of the important mills of the district the few tables that managed to hang on have finally given way.

On the straight-lead ores, tables and jigs are still used; and, due to better classification, their hold on this job has been strengthened.

ORES OF THE DISTRICT

The ores of the district are of two general classes: (1) clean lead ores, such as those from the Bunker Hill and Hecla mines, and (2) complex lead-zinc ores.

The general impression prevails that the clean lead ores, class 1, are simple and that it is easy to obtain high recoveries and good grade products. This, in a way, is a false impression; there is quite a high percentage of locked middling in these ores at 100 and 150-mesh sizes. Improved classification preparatory to table treatment of this type of ore has made it possible to segregate effectively a high grade middling which is further comminuted and floated.

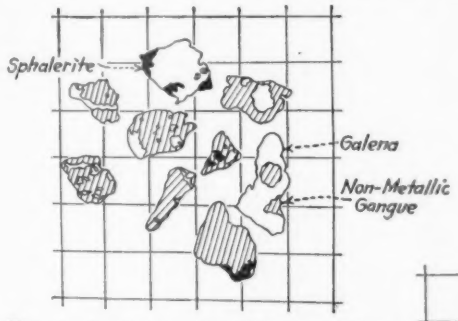


Fig. 1—Lead-zinc Ore, Morning Mine, Mullan, Idaho. Polished surface of —170 + 200 *mesh* (0.081 *mm.*) *particles.* × 180. (*Camera Lucida Drawing*)

Note.—Sixty-five percent of all grains are intergrowths as shown; balance of grains are free or nearly free.

The complex lead-zinc ores of the district, of which the ore from the Morning mine of the Federal Mining & Smelting Co. is a typical example, always have presented a difficult problem. It always has been comparatively easy to make a clean lead concentrate, but it never has been possible to concentrate sphalerite with a specific gravity of 4.10 from siderite of gravity 3.88. Also, a large percentage of the galena and sphalerite of this class of ore refuses to separate out until the crushing has been carried to —200 mesh. Tables gave way in all cases, only after flotation had proved to be better. It might be mentioned here that in the past the poor quality ore dressing was due to insufficient pulverization more than to any other factor. There can be no concentration where there is no liberation of the minerals.

Figs. 1, 2 and 3 (camera lucida drawing) show polished surfaces of —170 + 200 mesh particles of ore from the Morning mine, the Star mine and the Constitution mine, respectively.

Similar examinations of flotation middlings (cleaner tails) show that locking of minerals persists at sizes much finer than 500 mesh and that this is the explanation, most often, for high tailings and poor grade flotation products.

OPERATING COMPANIES

The name and location of the major companies, the nature of the ore and the general milling scheme are given in Table 1. The table is self-explanatory, and the data therein are quite complete. It may be observed that gravity concentration plays a comparatively minor role.

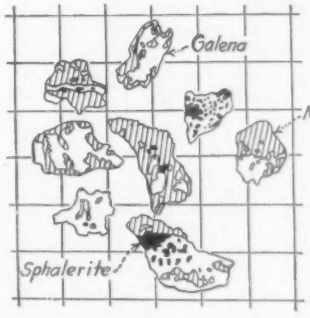


Fig. 2—Lead-zinc ore, Star Mine. Polished surface of —170 + 200 *mesh* (0.081 *mm.*) *particles.* × 180. (*Camera Lucida Drawing*)

Note.—Forty-eight percent of all grains are intergrowths as shown; balance of grains are free or nearly free.

FINE GRINDING PRACTICE

Fine grinding practice in the districts may be seen in considerable detail in Table 2, which shows also the fineness of grinding for flotation in the column headed "Classifier Overflow." Hardinge ball mills seem to be the favored mill, although quite a number of short cylindrical mills are to be found in the smaller plants, and they are well liked. At all plants the ball mills are operated in closed circuit with Dorr or drag classifiers. The Esperanza type classifier has been long used in the Coeur d'Alene district; the main reason is its low first cost. In some of the newer mills, such for example, as the Hecla jig tailing mill and the Galena mill of the Callahan Lead-Zinc Co., are found Dorr classifiers of the duplex type. Generally they are more efficient both mechanically and metallurgically than the Esparanza drag classifier. This is due largely to the better mobility and higher pulp density maintained in the Dorr classifier by the stirring action of the sand rakes.

The classifier in closed circuit with the fine grinding mill generally is amply large, permitting of high circulating loads—from 300 to 500 percent of the original feed. This provides for rapid passage of the pulp through the grinding medium and in turn a minimum reduction for each pass through the mill.

This practice, although not fully understood or appreciated by all operators, inadvertently results in high classifier efficiency. The explanation is in the large circulating load of coarse particles which sink in the classifier tank displacing upward an equivalent volume of water. This displaced water rises in the voids of the coarser particles, lifts and carries over the fine sands and slimes. The greater the circulating load for a given ball mill and classifier, the higher the ball mill efficiency, chiefly because of the higher classifier efficiency which this practice gives. The large circulating load of coarse particles gives a condition in the "mechanical" classifier which approaches that of hindered settling.

In the fine grinding practice in the Coeur d'Alene district, grinding is done at pulp dilutions of about 70 percent solids.

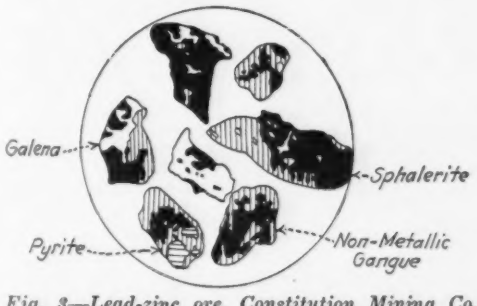


Fig. 3—Lead-zinc ore, Constitution Mining Co. Polished surfaces of + 2.94 *gravity,* —150 + 200 *mesh* (0.089 *mm.*) *particles. All particles less than* 2.94 *sp. g.* (64 *percent of total*), *considered as tailing, were removed.* × 180

* Presented at Joint Meeting of Western Division, The American Mining Congress, and Utah Chapter, A. I. M. M. E., Salt Lake City, Utah, August, 1927.

† Ore dressing engineer, United States Bureau of Mines, Moscow, Idaho.

TABLE I—PRINCIPAL OPERATING COMPANIES * IN THE COEUR D'ALENE DISTRICT, IDAHO; NATURE OF THE ORE MILLED AND MILLING METHODS

Company	Location of Office	Name of Mill	Mill Reference No.	Mill Superintendent	Nature of Ore		Milling Method
					Ore Minerals	Gangue Minerals	
Hecla Mining Co.	Wallace	Old mill at Gem	1	W. L. Ziegler	Argentiferous galena	Quartz, quartzite and siderite	Jigs, tables and flotation. Lead concentrate made.
Hecla Mining Co.	Wallace	Jig tailing flotation mill	2	W. L. Ziegler	Argentiferous galena	Quartz, quartzite and siderite	All flotation. Lead concentrate made.
Calahan Zinc-Lead Co.	Wallace	Galena mill	3	Ray McKinley	Galena, tetrahedrite, sphalerite, and pyrite	Quartz, quartzite and siderite	All flotation. Lead concentrate made.
Federal Mining & Smelting Co.	Wallace	Morning mill	4	M. P. Dalton	Galena and sphalerite	Siderite and quartzite	All flotation. Lead and zinc concentrates.
Federal Mining & Smelting Co.	Wallace	Page mill	5	M. P. Dalton	Galena and sphalerite, both silver-bearing	Quartzite gangue and some siderite	All flotation. Lead and zinc concentrates.
Bunker Hill & Sullivan Mining & Concentrating Co.	Kellogg	Old Westmill	6	R. S. Handy	Argentiferous galena	Quartzite and siderite	Jigs, tables and vanners and flotation. Lead concentrate made.
Bunker Hill & Sullivan Mining & Concentrating Co.	Kellogg	South mill	7	R. S. Handy	Galena and sphalerite	Quartzite, siderite and some pyrite	Jigs, making waste, otherwise all flotation. Lead and zinc concentrates.
Bunker Hill & Sullivan Mining & Concentrating Co.	Kellogg	El Hambra	8	Roy Hooper	Lead-silver antimonial ore	Quartzite and iron minerals	All flotation. High silver concentrate.
Bunker Hill & Sullivan Mining & Concentrating Co.	Kellogg	Sweeney mill	9	R. S. Handy	Galena and sphalerite	Quartz and quartzite	Same as 7.
Hays Co.	Kellogg	Hays mill	10	Arthur Hays	Galena-silver old Bunker Hill River bed tailings	Quartzite and siderite badly decomposed and polluted with organic matter	All flotation. Lead-silver concentrate.
Constitution Mining & Milling Co.	Masonia	Mill on Pine Creek	11	W. P. White †	Galena and sphalerite, and some pyrite	Quartz, quartzite slate and gangue	All flotation. Bulk lead-zinc concentrates.
Hercules Mining Co.	Wallace	Old mill rebuilt for custom flotation	12	J. P. Thatcher	Argentiferous galena and sphalerite	Quartz, quartzite, some magnetite, pyrite, and siderite	Tables, but chiefly flotation. Lead and zinc concentrates.
Tamarack & Custer Consolidated Mining Co.	Wallace		13	Harry Stewart	Galena, sphalerite	Quartz, quartzite, siderite, magnetite, pyrite	Jigs, tables and flotation. Lead and zinc concentrates.
Ore.-Idaho Mining & Milling Co.	Portland, Oreg.	Snow storm rebuilt	14	Clarence Thom	Chalcocite, bornite and chalcopyrite	Quartzite	All flotation. Copper concentrate.
Highland Surprise Mining Co.	Kellogg	Mill on Pine Creek	15	Dempster	Galena and sphalerite	Quartz, quartzite, slate, pyrite	
Hull Leasing Co.	Wallace	Mill at Gem	16		Galena and sphalerite	Quartz, quartzite, siderite	All flotation. Lead and zinc concentrates.
Jack Waite Co.	Kellogg		17	Mike H. Savage			

* Several small companies are not included, and two new modern mills are in course of design. † Manager.

TABLE 2—FINE GRINDING PRACTICE IN THE COEUR D'ALENE, IDAHO FLOTATION PLANTS

Mill Number (See Table 1)	Ball Mill			Feed Maximum Size	Solids in Mill Discharge per cent	Circulating load, percentage of original feed	Tons per day	Classifier		
	Name	Units	Size					Make and Size	Dragover Mesh and Percentage	Overflow (Flotation Feed) Mesh and Percentage
1	C & W Hardinge Grinding jig and table midds.	1 1	5 by 6 ft. 6 ft.	7 mm. 16 m.	50 80	300	800	Drag	C & W mill — 2 mm. round hole screen Hardinge 10% +200	
2	Hardinge	3	8 ft. by 36 in.	—30 mesh round hole	65	300	575	4 ft. by 6 in. by 18 ft. Dorr duplex	+ 8— 3.5%; + 14— 9.8% + 28—25.4; + 48—39.8 + 65—10.9; +100— 3.4 +200— 2.7; —200 3.8	+ 48— 3.5% + 65—11.0 +100—15.0 +200—18.0 —200—52.0
3	Hardinge	1	8 ft. by 22 in.	—¾ in.	70	500	150	6 ft. by 20 ft. Dorr duplex	+ 8— 3.0%; + 14— 4.1% + 28— 6.2; + 48—10.1 + 65—21.2; +100—25.0 +200—26.0; —200— 4.4	—200—10%
4	Hardinge ball Hardinge pebble	4 2	8 ft. by 36 in. 8 ft. by 36 in.	—1½ in.	80	400	1,200	Drag double belt	+ 8— 0.5%; + 14— 2.0% + 20— 2.0; + 28— 6.6 + 35—13.2; + 48—13.4 + 65—20.5; +100—20.5 +150— 8.8; +200— 4.1; —200— 7.4	
5	Hardinge	1	8 ft. by 36 in.	—2½ in.	80	400	275	Drag double belt	Not available	Not available
6	Hardinge		6 ft. by 22 in.	—7 mm.	23					
7	Hardinge	3	6 ft. by 22 in.	—7 mm.	50		300	Esperanza and Fahrenwald	Esperanza + 20— 0.4%; + 65—38.8% +100—20.3; +150—19.7 minus 200 — 20.8	Esperanza —150—99.0%
9	Hardinge Hardings	1 1	8 ft. by 30 in. 6 ft. by 22 in.	—¼ in. —20 mesh	50		200			
11	Hardinge P & M	1 2	6 ft by 22 in. 5 ft. by 5 in.	—¾ in.	60	300	150	Drag belt type	Note: Double classification practiced. Overflow from closed circuit classifier goes to second classification	Overflow second classification +100—1.8% +140—2.0; +170—4.7 +200—1.6; —200—89.9
12	P & M	1	7 ft. by 7 ft.	—½ in.		250 to 300	150	Drag		+ 48—1.7% + 65—6.7; +80—2.0 +100—8.3; —100—81.3 to 90
14	Hardinge	1	6 ft. by 22 in.	—½ in.	70		80			

TABLE 3—RELATION OF PULP DILUTION AND LOAD TO BALL MILL EFFICIENCIES

Test	Ore, Gm.	Pulp Ratio	Water, Gm.	Weight, +100 Mesh, Gm.	Weight, —100 Mesh, Gm.	—100 Mesh Percent
1	1,500	75:25	500	17	1,493	98.9
2	1,500	50:50	1,500	61	1,439	95.8
3	1,500	25:75	4,500	193	1,307	87.1
4	1,500	80:20	375	55	1,445	96.3
5	2,000	75:25	666	100	1,900	95.0
6	2,000	66:33	1,000	110	1,890	94.5
7	2,000	50:50	2,000	186	1,814	90.7
8	2,000	80:20	500	122	1,878	93.8
9	2,500	80:20	625	588	1,912	76.5
10	2,500	70:30	1,070	372	2,128	85.2
11	2,500	60:40	1,660	473	2,027	81.0
12	3,000	80:20	750	1,010	1,990	65.4
13	3,000	70:30	1,290	994	2,056	68.6
14	1,500			215	1,285	85.8
15	2,000			562	1,438	71.8
16	2,500			1,004	1,496	59.8
17	3,000			1,536	1,464	48.8

TABLE 4—RELATION OF CLASSIFIER EFFICIENCY TO BALL MILL EFFICIENCY
(Assumed efficiency of classification 100 percent.)

Charge, Gm.	Weight, +100 Mesh, Gm.	Weight, —100 Mesh, Gm.
2,500[2]	1,034	1,466
1,034[1] 1,466[2]		
2,500	928	1,572
928[1] 1,572[2]		
2,500	1,102	1,398
1,102[1] 1,398[2]		
2,500	739	1,761
739[1] 1,761[2]		
2,500	931	1,569
931[1] 1,569[2]		
2,500	1,029	1,471
1,029[1] 628[2]		
1,657	214	1,443
214[1]	0	214
		10,894

[1] Sand product from screen.
[2] Original ore.

Experimentation in the laboratory as well as in the plants has shown that the ball mills operate most efficiently at this density. Miller[1] and Fahrenwald conducted a series of experiments in a laboratory ball mill in which the variables were (1) the weight of the charge, and (2) the dilution of the pulp. The charge in all cases was —14+65 mesh complex lead-zinc ore. The results of the experiment are shown in Table 3. These data indicate clearly that both dilution and load are factors calling for careful regulation to obtain maximum grinding efficiencies with ball mills, and that the best dilution is from 25 to 35 percent moisture.

The results of another laboratory experiment conducted by Miller and Fahrenwald designed to throw some light on ball mill efficiency as related to classifier efficiency are given in Tables 4, 5 and 6. In this experiment the ball mill charge was taken at 2,500 gm. and the dilution at 30 percent moisture, since the data of Table 3 show this to be the best ball mill conditions. The initial charge was of the —14+65 mesh ore as used in the first experiment, and the length of each grind was 10 min. The total charge to be ground was 24 lb., and the finished product was to be —100 mesh. Classification after each grind was done by screening with a 100-mesh Tyler sieve. Classifier efficiencies of 100, 80 and 60 percent were assumed. By 100 percent classifier efficiency is meant that after each grind only the +100-mesh material was returned to the ball mill along with enough original ore to make up the required ball mill load of 2,500 gm. By 80 percent efficiency is meant that in addition to the +100-mesh material left after each 10-min. grind, 20 percent of the —100-mesh material was returned to the ball mill along with sufficient original —14+65-mesh ore to make up the proper ball mill load of 2,500 grams.

The grinding and screening processes were carried on alternately for each of the assumed classifier efficiencies until the original 24 lb. of ore were ground to —100 mesh. The efficiency of the ball mill for the three different classifier efficiencies is shown in Table 7. For each 1 percent decrease in classifier efficiency there is a drop in ball mill efficiency of approximately 0.4 percent. This experiment, while the conditions do not conform in all regards to actual mill conditions, is, nevertheless, a good indication of the significance of good classification in present fine grinding practice. Screen analyses (Table 8) of the final —100-mesh products resulting from the three sets of grinding conditions are also of interest.

[1] T. H. Miller, Fellow Univ. of Idaho, 1925-26; Master's Thesis.

TABLE 5—RELATION OF CLASSIFIER EFFICIENCY TO BALL MILL EFFICIENCY
(Assumed efficiency of classification 80 percent)

Charge, Gm.	Weight, +100 Mesh, Gm.	Weight, —100 Mesh, Gm.	Weight, —100 Mesh, Material Produced, Gm.
2,500[2]	1,055	1,445	1,445
1,055[1] 289[3] 1,156[2]			
2,500	888	1,612	1,323
888[1] 322[3] 1,290[2]			
2,500	494	2,006	1,684
494[1] 401[3] 1,605[2]			
2,500	722	1,778	1,377
722[1] 356[3] 1,482[2]			
2,500	739	1,761	1,405
739[1] 352[3] 1,409[2]			
2,500	952	1,548	1,196
952[1] 309[3] 1,239[2]			
2,500	704	1,796	1,487
704[1] 359[3] 411[2]			
1,474	35	1,439	1,080
35[1] 268[3] 0[2]			
303	0	303	35
			11,032

[1] Sand product from screen.
[2] Original ore.
[3] Slime product from screen.

TABLE 6—RELATION OF CLASSIFIER EFFICIENCY TO BALL MILL EFFICIENCY.
(Assumed classifier efficiency 60 percent)

Charge, Gm.	Weight, +100 Mesh, Gm.	Weight, —100 Mesh, Gm.	Accumulative —100 Mesh, Gm.
2,500[2]	995	1,505	1,505
995[1] 602[3] 903[2]			
2,500	595	1,905	1,303
595[1] 762[3] 1,143[2]			
2,500	392	2,108	1,346
392[1] 842[3] 1,266[2]			
2,500	409	2,091	1,249
409[1] 836[3] 1,255[2]			
2,500	355	2,145	1,309
355[1] 858[3] 1,287[2]			
2,500	349	2,151	1,293
349[1] 860[3] 1,291[2]			
2,500	361	2,139	1,279
361[1] 856[3] 1,283[2]			
2,500	402	2,098	1,242
402[1] 839[3] 35[2]			
1,276	0	1,276	437
0[1] 510[3] 0[2]			
510	0	510	10,963

[1] Sand product from screen.
[2] Original ore.
[3] Slime product from screen.

TABLE 7—RELATION OF CLASSIFIER EFFICIENCY TO BALL MILL EFFICIENCY

Sample No.	Classifier Efficiency, Percent	Number of Grinds	Weight of ore Reduced Gm.	Grinding Time, Min.	Gm. per Min.
1	100	6	9,237	60	153.9
2	80	7-4	9,927	70	141.8
3	60	8	10,526	80	131.5

TABLE 9—SUMMARIZED COEUR D'ALENE, IDAHO, FLOTATION PRACTICE AND RESULTS

Reference Number (See Table 1)	Flotation Machines	Chemicals and Oils P. P. T.	Metal Content in Flotation Products			
			Feed, Percent.*	Lead Concentration, Percent.*	Zinc Concentration, Percent.*	Tailings Percent.*
1	1 8-cell M. S. "Sub-A" 18 in. 1 8-ft. Callow	Cresylic acid, 0.2; soda ash, 0.1; xanthate, 0.1. Added to first cell of machine. Barrett's No. 4, 0.2.	Pb, 8.0 Ag, 4.5 Zn, 0.8 Fe, 8.0	Pb, 50.0 Ag, 28.0 Zn, 4.0		Pb—1.2; Ag, 0.8. Retreated by flotation reduced to Pb, 0.6 and Ag, 0.3 oz.
2	3 8-cell 18 in. M.S. "Sub-A." Seven used as roughers and 3 as cleaners. 2.4 h. p. per cell.	Soda ash, 0.05; xanthate, 0.01 and cresylic acid, 0.02 head of flotation machine and to cells. Added to Barrett's No. 4, 0.05 and cresylic acid, 0.04 to ball mill.	Pb, 1.2 Ag, 0.8	Pb, 45 0 Ag, 32.0		Pb, 0.13 Ag, 0.09
3	1 10-cell 18 in. "Sub-A." Seven cells as roughers and 3 as cleaners; power required 2.4 h. p. per cell.	$ZnSO_4$, xanthate and Barrett's No. 4 fed to ball mill. Pine oil, 0.05, ahead of flotation machines and to individual cells.	Pb, 6 0 Ag, 4.5 Zn, 1.2 Fe, 17.0	Pb, 53.0 Ag, 38.0 Zn, 8.0		Pb, 0.5 Ag, 0.42
4	Lead section roughers; 8 6-comp. O & D. Cleaners: First cleaners, 2 3-comp. O & D; second cleaners 2 3-comp. O & D. Zinc section roughers: 2 8-cell 24 in. M. S. "Sub-A" and 26 10-ft. Callows. Cleaners: 13 10-ft. Callows.	Galena: $ZnSO_4$ to ball mill; xanthate, 0.066; $ZnSO_4$, 0.72, and wood creosote Cleveland Cliffs No. 1, 0.106. Sphalerite: Xanthate, 0.21; Barrett's No. 4, 0.62; pine oil, 0.19, and $CuSO_4$, 1.15 to Callow section. Same to M. S. but less.	Pb, 8.7 Zn, 5.4 Fe, 16.0 Ag, 4.0 Insoluble, 39.7 Mn, 4.3 S, 4.7 CaO, 1.2	Pb, 63.1 Zn, 8.3 Fe, 4.0 Ag, 26.5 Insoluble, 2.0	Zn, 48.0 Pb, 4.0 Ag, 4.8	Pb, 0.85 Zn, 0.50 Ag, 0.30
5	Lead section roughers: 1 8-cell 24-in. M. S. "Sub-A" and 3 10-ft. MacIntosh cells. Cleaners: 2 10-ft. Callows. Zinc section roughers: 1 8-cell 24 in. M. S. "Sub-A" and cleaners 2 10-ft. Callows.	Same as mill No. 4. Note: This is a new mill in operation only since December, 1926, and data are not average, but approximately correct.	Pb, 6.6; Zn, 2 8; Ag, 2.2; Insoluble, 80.0; Fe, 2.2; Mn, 0.1; S, 3.2; CaO, 1.5.	Pb, 58.0 Zn, 9.5 Ag, 18.0	Zn, 48.0 Ag, 4.8 Pb, 4.0	Pb, 0.85 Zn, 0.50 Ag, 0.30
6	6 Parker cells, 2 Callow cells, and 1 Hearing cell.	K-xanthate, 0.01, and pine oil, 0.24.		Pb, 62.0		Pb, 0.45
7	Lead roughers: 2 10-cell 16-in Fahrenwald machines in series. Cleaners double cleaning practiced in 2 Hearing cells. Zinc roughers: 2 10-cell 16-in. Fahrenwald cells in series. Cleaners double cleaning in two Hearing cells.	Galena flotation: NaCn, 0.28, added to surge tanks. K-xanthate, 0.04, ahead of lead rougher. Sphalerite: $CuSO_4$, 2.0; Na_2CO_3, 1-5 and xanthate, 0.05.	Pb, 6.1 Zn, 10.4	Pb, 58.1 Zn, 14.8	Zn, 49.2 Pb, 5.3	Pb, 0.82 Zn. 1.20
8	1 10-cell 16-in. Fahrenwald. First 2 cells cleaners and balance roughers.					
9	Lead roughers: 1 10-cell 16-in. Fahrenwald. Lead cleaners: 1 Hearing cell. Zinc roughers: 1 10-cell 16-in. Fahrenwald. Zinc cleaners: 2 Hearing cells.	Galena flotation: NaCn, 0.5, and Na_2CO_4, 0.9, to surge tank. Xanthate, 0 03, head of flotation machine. Barrett's No. 4, 0.3. Sphalerite: $CuSO_4$, 1.0, added to surge tank; xanthate, 0.08, added ahead of flotation machines.	Pb, 7.0 Zn, 13.8	Pb, 58.81 Zn, 11.06	Zn, 48.78 Pb, 4.83	Pb, 0.51 Zn, 1.62
10	4 8-cell 16-in. Fahrenwald machines.					
11	Roughers: 3 O & D, 7½ h. p. each; 1 3-cell K & K requiring 8 h. p.; 3 Hearing cells requiring cu. ft. air at 4 lb.; 1 4-cell Fahrenwald requiring 6 h. p. Cleaners: 4 O & D primary and 2 Hearing cells as final cleaners.	45-min. treatment in 3 6 by 8 ft. surge tanks with $CuSO_4$, 1.5; Barrett's No. 4, 0.10; K-xanthate, 0.10; NaCn, 0.12; lime, 1.5, and pine oil, 0.15. Tailings from primary and final cleaners return to surge tanks.	Pb, 4 81 Zn, 9.97 Fe, 4.10 Ag, 2.8	Collective Flotation Zn, 43.53 Pb, 18.09 Ag, 11.4 Insoluble, 4.93 Fe, 5.8		Pb, 1.34 Zn, 1.42 Ag, 0.50
12	Lead roughers: 1 12-cell Fahrenwald 18-in. impellers requiring 2 h. p. per cell. Lead cleaners: Hercules pneumatic cells. Zinc roughers: 1 10-cell 18-in. M. S. "Sub-A" requiring 1.6 h. p. exclusive of auxiliary air. Zinc cleaners: Hercules pneumatic cells.	Galena: Xanthate, cyanide, zinc sulfate, sodium sulfide, barium sulfide, soda ash, lime, sodium silicate, added in varying amounts and combinations, some to ball mill and some to flotation machine. Oils: Pine oil, Barrett's No. 4, hardwood creosote, and cresylic acid in varying amounts and combinations. Sphalerite: Xanthate, soda ash, copper sulfate, sodium sulfide, lime, just preceding circuit. Oils: Pine oil, Barrett's No. 4, P. E. oil in varying amounts and combinations.	Custom mill. Some 15 different ores treated—assay varies widely.	Pb, 58 to 68 Zn, 2 to 10	Zn, 47 to 54 Pb, 1 to 4.0	Pb, 0.4 to 1.3 Zn, 0.2 to 0.4
14	2 4-cell 15-in. Fahrenwald machines, one cell used as cleaner and seven as roughers.	Soda ash, 0.5 added to ball mill; 0.1 xanthate added part at ball mill and part to flotation machines. Cleveland Cliffs No. 1 and No. 5 pine oil.	Cu, 2.5 Fe, 0.5 Insoluble, 95.0	Copper concentration Cu, 40.0 Sb, 0.5 Fe, 1.0 Insoluble, 15 0		Cu, 0.6 Mostly as carbonate.

* Silver in ounces.

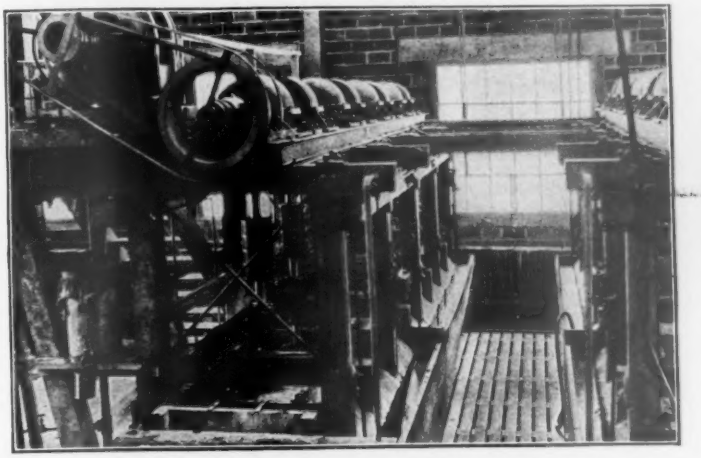


Fig. 4—Minerals Separation "Sub. A" machines in Hecla tailing mill, showing tex rope lineshaft drive

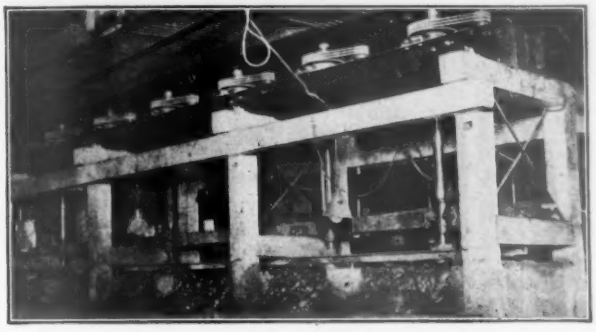


Fig. 5—Fahrenwald 10-cell flotation machine, showing individual motor and tex rope drive 10-cell units in Bunker Hill south mill

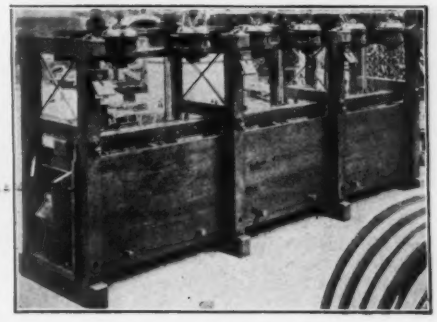


Fig. 6—Fahrenwald 6-cell machine showing a better way of installing the small 3-hp. a. c. motors

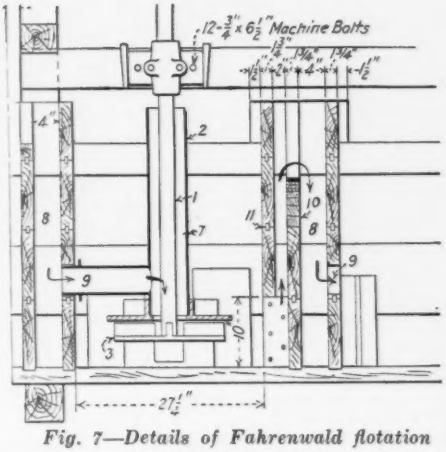


Fig. 7—Details of Fahrenwald flotation machine

TABLE 8—SHOWING OVER-GRINDING EFFECT DUE TO POOR CLASSIFICATION

Sample No.	Classifier Efficiency, Percent	Weight Total, Gm.	Weight, —200 Mesh, Gm.	—200 Mesh Percent.
1	100	9,237	5,200	56.3
2	80	9,927	6,340	63.88
3	60	10,526	7,700	73.16

High density classifier feed (ball mill discharge) also is favorable to high classifier efficiency, particularly if the overflow is to be in the neighborhood of, say, 35 to 65 mesh. If a —200 mesh classifier overflow is wanted, high pulp density in the classifier must be avoided. It may be necessary, when very fine overflow is wanted, to add water to an extent that thickening of the classifier overflow—which in most flotation plants is the flotation feed—will be required.

One of the chief criticisms of the straight mechanical classifier is its inability to give a uniform overflow under variable load conditions; however, on the other hand, this inability makes for constant ball mill loads, because if the ball mill feed temporarily decreases the classifier overflow automatically becomes finer, i. e., more intermediate and normally finished sands are dragged back into the ball mill with the original feed. On the other hand, if the feed temporarily increases, the classifier overflow will simultaneously overflow a coarser product and thereby cut down the drag-over return to the ball mill feed.

The cost of fine grinding in the district runs from 20 cents to 30 cents per ton of original ore crushed.

At the mill of the Constitution Mining Co. double classification is practiced — the overflow from Esperanza classifier, operating in closed circuit with the ball mills, receives a second classification in a second Esperanza classifier. The overflow from the second classifier, after it has been thickened, is the flotation feed and the drag-over goes to another ball mill operating in closed circuit with a Dorr classifier.

Flotation Machines

Minerals separation "Sub A," O & D, and the Fahrenwald flotation machines are used in the district. Old type Callow and Hearing cells are used as cleaners in some mills. The trend is decidedly toward multiple cell vertical shaft and impeller machines.

The operators and manufacturers in the district have given considerable attention to the mechanical details of their flotation machines, and as a result the district is probably ahead of others in this respect. Both M. S. and Fahrenwald machines are equipped with spiral bevel gears. This refinement has reduced the power required to operate the machines and the noise which is inherent in the old spur gear drive.

The tex rope method of transmitting rotation to both line shafts and vertical impeller shafts has come into common use. The tex rope was first used by W. L. Ziegler on his M. S. "Sub A" machines, shown clearly in Fig. 4.

Lawrence Day, of the Hercules Mining Co., made the first application in the district of the tex rope to vertical impeller shaft drive. At this company's plant a 12-cell (18-in. impellers)—six cells back-to-back—Fahrenwald machine is operated with three vertical Janney motors. The 10-h. p. motors were taken from some early model Janney machines standing idle in the mill. The motors are located between each set of four cells. Two tex ropes are used, one strand for each two impeller shafts, the motor pulley being a double sheave affair. The rope stretch is taken up, when necessary, by shifting the motors on their base.

Perhaps the neatest and most satisfactory application of the tex rope to vertical shaft transmission was made by R. S. Handy to his Fahrenwald machines in the south mill. Each impeller shaft

is provided with an individual 3-h. p. A. C. motor (Figs. 5 and 6). Three small strands of tex rope are used for each drive. These motors are equipped with ball bearings and run equally efficient in any position. They also are inexpensive and take up little space, as may be observed.

Because the Fahrenwald machine is, comparatively speaking, a newcomer—although it has been in operation in the Bunker Hill mills and a number of others for more than two years, and there are some 300 cells in operation in the district—a brief description of it may be of interest.

The novel features of the machine are (1) the method of air utilization, and (2) the method of pulp circulation.

Referring to Fig. 7 a solid shaft (1) operates in a stationary casing (2). Attached to the lower extremity of the solid shaft (1) is an impeller (3) which is simply a solid disk smooth on its bottom surface, but provided with four vanes on its top surface. The vanes are vertical and at right angles with each other. Just above and close to the top edges of the vane, is a stationary disk, or shroud (6), which is attached to the lower end of the casing (2). The rotation of the impeller, which generally is at 375 r. p. m., sucks air from the atmosphere down through the annular space (7) between stationary casing (2) and rotating shaft (1). The impeller functions as a blower. Simultaneous with this action, pulp flows into the casing (2) from the feed box (8) through the medium of pipe (9). Any and all pulp flowing into casing (2) falls on top of the rotating impeller and is ejected vigorously into the body of the pulp in the cell. The mixing of air and pulp at the periphery of the impeller is highly efficient. The circulation or flow of the pulp through the machine is by gravity and not suction, as in other machines of this general type. Any number of cells may be operated in series on the one level. The pulp level in each cell is independent of all other cells and the flow of the pulp through the cells in series is positive. Plug-ups are unknown.

The pulp level in each cell is controlled by an adjustable weir (10) which is preceded by a baffle (11) and succeeded by a narrow pulp overflow or feed box (8).

The power required to operate the 18-in. runner is 2 h. p.

The machines may be shut down for hours without draining the pulp from the cells, and started without attention.

The type of machine used seems to have little to do with the quality of ore dressing effected, but a machine has much to do with daily operation. Good continuous operation free from small troubles of one kind and another is economical.

M. S. and Fahrenwald machines are convenient and flexible for selective flotation work. Any number of cells may be installed on the one level and part of the string of cells may be used as cleaners and part as roughers. Generally, cleaning is done in the first one or two cells; the balance of the cells serving as roughers. The froth overflow from the roughers flows by gravity to the intake of cell No. 1 and the cleaner tails from cell No. 2, if two cells are used as cleaners, flow automatically into rougher cell No. 3. By this system the first two cells give a finished concentrate.

Reagents and Oils Used

Details on the use of the flotation reagents common in the Coeur d'Alene district are given in Table 9. No uncommon reagents are in use, and there is nothing particularly uncommon in the manner in which any reagents are used. Xanthate is used generally and its appearance brought considerable improvement in all mills.

Quality of the Ore Dressing

As may be seen from Table 9, the quality of the ore dressing in the Coeur d'Alene district is excellent; it is probably not surpassed by practice anywhere in the country. The operators have considerably more than average ability, and they have coped unusually well with the mystifying pranks of flotation. Little effort has been made by them to unravel the mysteries of flotation, and the steady headway is the result of intelligent experimentation.

It would seem that any future improvements by flotation will be only in the nature of small refinements.

The refinements in control of the process, such as in feeding reagents, controlling the grind and the pulp density, etc., have played an important part in bringing the process to its present perfection. More suitable reagents, such as xanthate, cyanide in an alkaline circuit, and zinc sulfate have, of course, helped most.

Theory of Flotation

To those interested in the theory of the process, let it be said that reference to Table 9, showing the reagents used, the order of their addition and the place of addition, will offer plenty of trouble. And yet, in the face of the results obtained and the consistency of the work, it can not be doubted that there are very definite forces, chemical and physical, at work. An overdose of any one of the reagents used is harmful.

Cost of Flotation

The grinding cost is the one big item in the general cost of flotation. This figure has been greatly lowered as all flotation concentration has progressed. This is due directly to (1) closed circuit grinding, (2) large circulating loads, and (3) high pulp density. It is not fair to compare grinding costs at different plants because of the different conditions which prevail, such as the nature of the ore and the fineness of the finished product. The cost of treatment in the flotation machine is also an item which will vary from plant to plant, because it depends on the nature of the ore with respect to grade, kind and number of minerals to be floated and fineness of the flotation feed.

The cost for reagents per ton of ore also is not an item which is expected to be constant at the various plants, and the factors which determine the cost of flotation machine treatment determine the cost of reagents per ton.

PRODUCTION OF METALS FROM SECONDARY SOURCES

THE recovery of certain metals from secondary sources in 1926 is reported to the United States Bureau of Mines as $274,540,900, which is $30,970,200 more than in 1925. This large increase in the total value of the recovered metals, according to J. P. Dunlop, who compiled the figures, occurred notwithstanding a lower yearly average price for all the metals covered in the inquiry other than for tin and nickel. The increases in the recoveries of copper, brass, lead, and antimony were very large.

The smelters that treat mainly ore recovered 112,559 tons of copper from scrap which was 13,000 tons more than in 1925. Part of the increase of 28,500 tons of copper in brass was due to the decrease of the exports of brass from 48,189 tons in 1925 to 25,132 tons in 1926.

The smelters that treat mainly ore recovered about 3,000 tons less lead from scrap and drosses than they did in 1925 but the secondary smelters recovered about 15,000 tons more lead. The increased quantities of battery plates from motor cars probably accounts for most of this large increase though the regular smelters reported an increase of more than 2,000 tons of lead in antimonial lead scrap.

Zinc recovered by redistillation increased more than 1,600 tons and that recovered by sweating and remelting more than 1,500 tons. The largest increase in zinc was that obtained from scrap alloys. The quantities of lithopone, zinc dust and zinc chloride made from drosses and skimmings were considerably less in 1926 than in 1925, and the exports of zinc dross declined about 5,500 tons.

The secondary tin recovered increased about 2,400 tons, partly owing to the treatment of large quantities of old cans and tin plate clippings. Tin plate clippings treated increased 22,000 long tons and old cans treated more than 10,700.

SECONDARY METALS IN CERTAIN CLASSES RECOVERED IN THE UNITED STATES IN 1925-26

	1925		1926	
	Short tons	Value	Short tons	Value
Copper, including that in alloys other than brass	250,600	$71,170,400	281,700	$78,876,000
Brass scrap remelted	242,300	56,270,800	283,000	65,918,000
Lead as metal	112,420	39,477,100	125,000	44,368,000
Lead as alloys	114,460		152,300	
Zinc as metal	61,430	11,359,000	64,570	11,700,000
Zinc in alloys other than brass	13,300		13,430	
Tin as metal	7,950	35,165,400	9,750	42,511,500
Tin in alloys and chemical compounds	23,000		23,650	
Antimony as metal	1	3,794,000	2,910	5,164,400
Antimony in alloys	10,839		13,320	
Aluminum as metal	17,700	24,816,000	20,500	23,868,000
Aluminum in alloys	26,300		23,700	
Nickel as metal	191	1,518,000	485	2,135,000
Nickel in nonferrous alloys and salts	2,109		2,565	
	.....	243,570,700	.....	274,540,900

Photo by H. S. Graves, Courtesy U. S. Forest Service.

PUBLIC LAND OWNERSHIP*

Problem Vitally Affecting Western States—Opinion In The East Largely Divided—Situation Complicated By Mineral Land Laws, Enlarged Homestead Acts And National Parks—Necessity For A Comprehensive Study Of The Situation Is Obvious

AS a premise, it may be stated that more than one-half of all the area west of a north-and-south line drawn through the eastern border of Colorado is still in Federal ownership.

Five Western States are particularly to be noted. In Nevada, 87 percent; Utah, 75 percent; Arizona and Idaho, 67 percent; and New Mexico, 43 percent of the area of the state belongs to the Federal Government.

The taxable areas of the commonwealths must police the whole state, build and maintain roads, and incur other necessary expenditures on account of a vast domain which they neither own nor control.

There remain 184,000,000 acres of unreserved and unappropriated public lands. These vary in quality from rich grazing land to arid desert. There are also 180,000,000 acres of sequestered parks and reservations. This acreage constitutes a special element in the consideration of the general problem, and is uppermost in the minds of the general public.

Then there are 45,000,000 acres granted under the general leasing act, which has in effect, a high royalty basis, and acts as a tax upon the western states, not assessed upon eastern states having similar resources.

Injected into the situation is the fact that in 1836 the 26 states then existing divided up $28,000,000 derived from the sale of public lands, and called it a "loan." None of this has ever been repaid, either in principal or interest, and it still stands on the books of the United States Treasury, charged against the several states as "unavailable funds."

It has been stated that the money for this distribution among the existing states, came from a surplus revenue of extraordinary amount for which the Federal Government, under the policies it was then pursuing, had no use; that the intention was to give it to the several states, who were then making the public improvements which the Federal Government had withdrawn from making; that against this proposal the question of constitutionality was raised, and since it was doubtful whether Congress could constitutionally give this money to the states, they distributed it in the form of a "loan," there being no intention that it should ever be called for.

An investigation of the records in the Congressional Library, and a perusal of Dewey's "Financial History of the United States" and Bourne's "History of the Surplus Revenue of 1837" shows the following to have been the situation:

At the close of the Revolutionary War the Federal Government come into possession of an enormous domain by the cession of claims by eastern states to western lands.

Washington and Jefferson held that the public debt could be met by their sale, but up to 1800 little cash was received. A radical change then took

* This article is the second of a series of five, prepared from information gathered by the Bureau of Mining Economics of The American Mining Congress, on five major national questions.

place, and many land offices were opened, with sales of land on credit.

By 1819 forfeitures had amounted to over $21,000,000, and the resulting panic caused the credit system to be abolished. Beginning with 1830, there was an increase in public land sales, and in 1836 for the first *and last* time revenue from this source exceeded that from the customs.

As early as 1832 a distribution of the proceeds to the newer states was discussed, and Jackson argued that "as the adventurous and hardy population of the West do not receive their proportionate share of enjoyments from the expenditures of Government, and as the real value of the land is due to their labor, they should be treated with special consideration."

In 1835 the national debt was paid off and Clay introduced a bill providing that 10 percent of the net proceeds of public land sales should be left in the Treasury and the residue deposited with the several states in proportion to their respective representation.

There were obvious reasons why Congress could not compel the states to apply the money to any specific object. Nor could it constitutionally make the appropriation for anything except certain definite purposes connected with the general welfare. One group desired it spent on fortifications, while others suggested that the surplus be invested in sound and saleable stocks.

The bill of 1836, as passed, made the states depositories of the moneys so apportioned, *subject to the demands of the Treasury*. In return, the Secretary of the Treasury received certificates acknowledging the obligations of the several states to pay the amount expressed to the United States or their assigns, and it was further provided that these certificates should bear 5 percent interest from the time of their sale or assignment, and should be redeemable at the pleasure of the States.

Under the terms of the act $37,000,000 should have been transferred but certain financial considerations reduced the amount to about $28,000,000. There were many who alleged that the moment the act was passed a contract was created between the states and the Federal Government calling for the full $37,000,000, and in 1883 the State of Virginia made a claim upon the Secretary of the Treasury for further payment, appealing to the Supreme Court of the United States for a mandamus to compel the Secretary to deposit $732,809 with the state.

The court held, however, that the act of 1836 created no debt or legal obligations on the part of the Government, but only made the states temporary depositories of a portion of the public revenue not then needed for the purposes of the United States.

As to common feeling at the time of its passage, Benton stated that: "The act is in name a deposit; in form a loan; in essential design a distribution."

Clay told his constituents in Kentucky that he did not believe a single dollar would be recalled.

Calhoun said in 1841 that he regarded it as a deposit to be drawn against only in case of war.

Governor Seward in his message of 1841 said it was well understood that the form of a deposit was adopted to save the bill from executive veto.

Notwithstanding these opinions the Treasury still carries the $28,000,000 on its books as part of its cash balance in "unavailable funds."

A series of enlightening articles upon the general problem appeared in THE MINING CONGRESS JOURNAL from January to May, 1927, inclusive, and the symposium of the national questionnaire, noted in our last issue, indicated widespread interest in the public land question.

These responses it will be recalled, were rather evenly divided, 37 percent of the replies favoring private ownership of public lands, 34 percent considering that the Federal Government should continue in control and 29 percent were unable to reach a conclusion, or favored modification of the present situation.

There appears to exist a strong feeling in favor of forest reserves and national parks, especially on the headwaters of our great rivers; such parks, reservations and lands under the general leasing act, to remain under the Federal Government; the balance to pass to private ownership wherever available for crop and grazing purposes.

In granting this, however, we must not lose sight of the fact that prospecting has been declining for several years, and that the extent and location of many of these parks, forests and reservations is such as to make them logical areas within which to look for minerals. The mining industry is entitled to equal enjoyment with others, of the public domain, and should not be unduly restricted in prospecting and locating bona fide mineral claims within the public lands, by endless red tape, bureaucratic supervision, and uncertain interpretation of existing regulations. The present land laws are so enacted and administered as to enable surface leases for grazing purposes, stock-raising homesteads and oil prospecting permits to interfere with prospecting for metals.

Many replies to the questionnaire expressed a desire for fuller information regarding the proportion of arid, semi-arid, and fertile acreage in the public lands, with the idea that all the resources of a state should be available upon a common basis of taxation for the benefit of the state.

The trend toward centralization of power in the Federal Government was scored by many, with the statement that it is manifestly unfair to the public land states that they should be subjected to a tax which is not assessed against eastern states.

The State of Wyoming for example, pays into the Federal Treasury approximately $1,000,000 a month in royalties upon its oil production, which is not assessed against Pennsylvania, Louisiana, Texas, West Virginia or other eastern oil producing states.

Nor are these public lands subject to taxation for the maintenance of roads, schools, courthouses, or asylums, or to furnish protection and enforce the law over territory which is exempted from paying its share of state support. It is true that a small portion of this royalty tax is paid back to the state treasury and a portion into the reclamation fund, but the erroneous principle remains.

The whole problem resolves itself into what is the most economic use of these lands, and what is the policy that will lead to elimination of gross abuses and produce a broad constructive development and equable distribution, with a fair return to the Federal Government on the one hand, and taxable resources to the individual states, on the other.

Upon no one of the five national questions submitted, was opinion so evenly divided. Some of the respondents stated that there is already too much land under cultivation, and favored more intensive farming. Others believe that it should be made available upon still easier terms to war veterans and homesteaders, to which view reply is made that it would soon revert and be sold for taxes.

One writer opposes leasing of public land for a depleting industry, believing that such land should be sold outright at a value fixed by Federal experts.

"Absentee Landlordism" and the "Government in the Real Estate Business," receive their share of criticism. Referring to the $28,000,000 distribution of 1836, a prominent business man says, "A business house would insist on collecting money due it. The money used by the states must have had an earning capacity and has therefore paid for itself and should be returned."

A manufacturer says that to pass the entire public domain to private ownership would relieve the unfairness done to the western states, but might in itself be unfair to future generations for whom should be reserved an equity in this domain for their disposition. As population grows, new sources of primary supply of raw products must be available, if the cost of living is not to rise disproportionately. The existence of this unoccupied public domain may be regarded as an economic balance between production and (*Continued on page* 746)

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Sunrise on the Potomac below Mt. Vernon.

METAL MINING LEGISLATION

Congress To Consider Wide Program—Tax Revision Outstanding Prospect—Blue Sky Regulation Will Be Renewed—Tariff Revision Not Expected—Silver Purchase And War Mineral Relief Proposals—Mine Patent Change Suggested

WHEN Congress convenes on December 5 for the first and long session of the new 70th Congress, a veritable flood of legislative proposals will be thrown into the bill hoppers by the nearly 550 members of the House and Senate. The Congressional slate will have been washed clean of all prior bills and the statesmen will begin to write a new chapter in the legislative history of the country. Members who have seen previous service in Congress will renew their legislative plans which failed of fruition in former sessions, together with new suggestions, while the several score of Congressmen who will begin for the first time their service in the field of national law-making will advance their ideas for improving the social and economic status of the country.

As Congress has been in a state of recess since March 4, the new session will give to all proposals, new and old, a fresh interest. Suggestions have been made that Congress be called into extra session a month or two earlier than the regular session in December in order to consider Mississippi River flood relief and prevention legislation and to expedite consideration of the other business to come before Congress.

Senator Reed Smoot, Republican, Utah, Chairman of the Senate Finance Committee, who in addition to being interested in the dispatch of general public business, will be in charge of the tax revision bill which Congress intends to pass, was one of those who favored an extra session. In fact, he announced recently, following a conference with the President, that the President would call an extra session in the fall. Senator Smoot is one who takes his legislative duties and the responsibility of Congress carrying out its business very seriously, and is considered one of the most painstaking and well-informed statesmen on Capitol Hill. The President, however, denied the authenticity of the announcement, and since then it has been generally conceded that the President will not convene Congress in advance of the December session, which is fixed by the Constitution.

Further wind has been taken out of the sails of extra session agitation by declarations of Congressmen who were among the first to suggest an extra session after the Mississippi flood revealed the toll of its disastrous results, that the time for emergency legislative action has passed and that there is now no occasion for Congress to meet before December. The President has consistently refused since he took office four years ago, to call extra sessions of Congress, and is likely to complete his service in the White House without having called an extra session. This will be a record in that his immediate predecessors called several extra sessions to revise the tax and tariff laws; to consider strike situations; and to prosecute war.

Tax Revision

Tax revision legislation, with its application to the metal mining industry, promises to be the outstanding feature of the forthcoming session of Congress. For more than a year a special investigation of the entire internal revenue system has been conducted by a specially created Joint Committee, composed of members of the House Committee on Ways and Means and the Senate Committee on Finance, which committees have charge of the preparation of tax bills. This investigation has covered primarily the application of administrative provisions of the revenue law to the mining industry, embracing depletion, depreciation, and other factors, as the committee was not authorized to make recommendations as to tax rates. Cooperating with the Joint Committee in these studies, expert assistance has been rendered by recognized authorities in the field of taxation. These experts were drawn by the committee from civil life and are rendering their services in the form of an advisory board. When the Ways and Means Committee of the House, which must originate tax legislation, begins the work of drafting a new revenue law on October 31, it will have the benefit of these investigations and be prepared to bring in as complete a revenue law as is possible. Both the Joint Committee and Ways and Means Committee will carefully consider provisions in the law affecting the metal-mining industry as recommended by the American Mining Congress and its tax division and general tax committee, based on studies conducted by these mining organizations and as finally drafted in their special consideration of the matter at the annual meeting of the Western Division of the American Mining Congress at Salt Lake in August.

"I am advised that there is very little sentiment in support of any general legislation affecting the mining industry," says Representative Addison T. Smith, Republican of Idaho. "The legislative program promulgated by the American Mining Congress at Salt Lake will be the basis of any action."

Congress in the tax revision bill is expected to recognize the merit of the mining industry for consideration of its wasting of ore reserves through proper allowances for depletion and depreciation. The mining industry will also be benefited through reduction of the income tax on corporations. It is generally recognized that the corporation tax has not been reduced in recent revenue revision bills to the same extent as the individual income tax rates, but the extent of the revision to be decided on by Congress is at present uncertain. Some Congressmen favor reduction of the corporation tax to 10 percent or lower, while others say it can not be cut to below 12 or 11 percent. Congress is also likely to repeal or reduce the tax on non-par value shares of stock, for which there has been a demand from mining interests. Consideration may also be given to exemption or lowering of the tax on domestic gold mining companies and their stockholders because of the depressed condition of the gold mining industry due to the stationary price of gold and increased production costs since the war. Exemption of these gold mining taxes will be urged by Representative Harry L. Englebright, Republican, of California. He introduced a bill to this effect during the closing days of the last session in order to put the question before the Ways and Means Committee in its consideration of the new tax bill.

"There is no doubt but that the new tax bill ought to take into account the exhaustion of mines, and make most liberal allowances and deductions for depletion," said Senator William H. King, Democrat, of Utah. "At the present time, however, I have no clear view as to how we ought to deal with depletion and discovery value. My present view is that the existing law needs modification favorable to the metalliferous mines. I favor a total tax reduction of $500,000,000. The corporation tax should be cut to 10 percent and perhaps lower, as corporations are now paying very heavy taxes."

Blue Sky Bill

Efforts will be renewed to enact Blue Sky legislation to restrict the issuance of mining and other securities. It is not

expected, however, that this legislation will succeed because of the opposition of mining and other interests. Representative E. E. Denison, Republican, of Illinois, has been the author of similarly proposed legislation in the past but has been unable to put the measure through. It is likely he will reintroduce his bill. In a recent Congress it was passed by the House but died in the Senate Committee. In the last Congress the measure was not brought to a vote in the House because it had been amended after it came from the committee to include all stock exchanges. A large amount of data is being secured by the American Mining Congress for use in consideration of this legislation. Prior bills have not received the full approval of Government agencies, including the Treasury Department, Department of Justice and Post Office Department, which has been a factor in the failure of this legislation.

Tariff Legislation

While proposals for tariff revision are expected to be advanced, Congress is not likely to disturb the present tariff law which has been in effect for the past five years. The President is a strong tariff protectionist and is opposed to tariff tinkering. Colorado mining interests have announced their opposition to tariff changes. Senator King expresses the opinion that Congress will not touch the tariff. "I do not think there will be any tariff legislation," he said.

Representative Charles E. Winter, Republican, of Wyoming, is reported as favoring a tariff on potash, phosphate and asbestos. Unless the entire tariff system is revised, Congress will not take up the duty on one or more tariff proposals on specific commodities.

Silver Purchase

Although the American Silver Producers Association has filed suit in the District of Columbia Supreme Court to compel the Treasury Department and Mint Bureau to purchase 15,000,000 ounces of silver at $1 per ounce to complete purchases under the Pittman Act, legislation to require this purchase is expected to make its reappearance at the coming session of Congress. A bill to this effect, introduced by Senator Key Pittman, Democrat, of Nevada, was passed by the Senate in the last two Congresses, but failed to reach a vote in the House. "I will press the silver bill for passage," said Senator King. "The pendency of the suit of the silver association ought not to stop Congress from passing this legislation. I consider that the matter involves a moral obligation on the part of the Government. Of course, I will be guided in my action by the wishes of the silver producers. If they prefer to wait on the courts for a decision of the issue, I will accept their view. But knowing as I do the long course of litigation, the question may be held up in the courts for many years, and Congress should feel free to act. The Government made a contract with the silver producers and is under obligation to carry it out. If legislation can be secured on the subject it would be better than waiting on the courts. The pendency of the suit ought not to prevent Congress from doing its duty toward the silver producers." Senator Tasker L. Oddie, Republican of Nevada, will also work for the legislation.

War Mineral Relief

Further attempt will be made to have Congress amend the War Mineral Relief Act by authorizing adjustment of claims on account of purchase of property, interest on borrowed capital, and for review of claims by the Court of Claims. This legislation has been favorably acted on by the Senate but has failed to pass the House. Senator Oddie will take a leading part in pressing for action on this legislation.

Mining Claims

A change in the procedure under which persons may obtain patent for mining claims will be advocated by Senator King. "The law should be liberalized so that a person seeking title to a mining claim could have one hearing before the state court nearest his claim which would do away with the long involved process now required," said Senator King. "There have been many cases where it has taken from 5 to 10 years to obtain a patent. Under the present system if a claimant receives a favorable ruling from the Interior Department, he must still run the risk of an adverse claim. A hearing by a local court would benefit the claimant as such court is likely to be in sympathy with the mining industry, understanding its difficulties and problems. After the court decided that a claimant was entitled to a patent, the Interior Department would upon receipt of the decision issue the patent. This course would abolish hearings before the local land office and the various bureaus of the Interior Department. The court action would permit all questions involved to be considered and the rights of all parties, including individuals and the Government to be settled in a single action before one court. At present the right of possession must be determined by a court.

"I have always favored granting the public domain to the states," continued Senator King. "The states could handle the public lands better than the Federal Government. But that is perhaps a dream which may not be realized. The present law regarding mining claims is not liberal enough for the present situation. The Interior Department has been too rigid in its interpretation of the mining laws. Some of its regulations have been harsh and oppressive. Under the divided authority over the public domain, including mineral lands, the acquisition of a patent is a difficult matter. The Geological Survey, Forest Service, and General Land Office are all concerned in the matter and a person applying for a patent must run the gamut of these bureaus. The very intent of the law is against the applicant. The law considers or is construed to assume that the applicant is not acting in good faith and has not complied with the necessary rules and regulations. I am informed that the Government is now bringing suit against persons who have been in possession of mineral lands for a long time. Not waiting for the applicant to bring an action to obtain title, the Government will enter suit to prevent him from remaining in possession of the mining claim, alleging that it is not mineral land or that he has not performed the necessary amount of assessment work. The applicant is subjected to embarrassment and difficulty in getting title to the land, and it has operated to discourage poor men from prospecting and locating on the public domain. The result has been that prospecting is now done by large corporations rather than by the ordinary miner. In addition to the applicant satisfying the Geological Survey, Forest Service, and General Land Office that he has met all requirements, the Reclamation Bureau must also pass on whether the land is needed for reservoir purposes. Some mining claims are within lands which have been withdrawn ostensibly for reservoir purposes but which are not valuable for such purpose."

Other Western Senators and Representatives are generally sympathetic toward legislative proposals for the benefit of the mining industry. "I am very much interested in doing whatever may be necessary to promote the welfare of the mining industry," said Senator W. L. Jones, Republican of Washington. "I will aid all desirable legislation in every way possible."

"I shall be at least sympathetic toward any plan to enact legislation that is particularly needed by the mining industry," said Senator John B. Kendrick, Democrat of Wyoming.

The close of the coming session is indeterminate, but it is likely to continue at least until June, when the Presidential nominating conventions will be held.

THE ANTHRACITE INDUSTRY

Its Importance To Pennsylvania—Close-Up Picture Of The Industry—Taxes Add To Production Cost—Reason Should Govern Settlement Of Wage Controversies

By E. W. PARKER*

THIS year, if the commercial production of anthracite reaches its normal figure of about 72,000,000 gross tons, the amount of money put into circulation in the anthracite region by the pay rolls of the anthracite mines will be well in excess of $300,000,000—practically all coming from points outside the region, for the quantity of anthracite sold locally is relatively unimportant. That is, for every possible working day in the year more than $1,000,000 comes from other sections of the country into this little area of less than 500 square miles and having a population of about 1,300,000 souls; nearly $250 a year to each inhabitant. This includes the city of Harrisburg, which is located in Dauphin, one of the anthracite-producing counties.

It is this inflow of money distributed through the pay rolls of the anthracite-producing companies that has made this anthracite region, per capita, the most prosperous section of the United States, if not of the entire world. Is it your desire that it shall continue to be so? I imagine it is. Then contemplate these figures:

As I have said, the pay rolls of the companies will distribute in the anthracite region this year, provided a normal tonnage is mined and sold, something over $300,000,000. In 1913, the year before the outbreak of the World War, the commercial production of anthracite was 71,000,000 tons, just about what we have good reason to believe it will be this year, and the pay roll was $113,320,000—a little more than one-third of what it will be this year. The labor cost per ton in 1913 was $1.60—now it is about $4.60. And while the labor cost has almost trebled, other factors entering into the cost of production have borne no more lightly on the industry. Take taxes, for example. Do any of you realize to what an extent your state, county and municipal authorities are sucking the life blood of this industry upon which your bread and butter and the prosperity of the region depend?

In 1913 the taxes paid by the anthracite-producing companies amounted to a little more than $5,660,000, of which, in round numbers, the state capital stock tax took $1,000,000, the counties $1,800,000, and the municipal authorities $2,800,000. There was no state tonnage tax in 1913.

Now, consider what these same companies paid in 1924 on practically the same tonnage. The capital stock tax going to the state treasury drew $1,233,000, an increase of only about 25 percent, while the state also helped itself to $4,066,000 through the iniquitous (so called by your late Governor Pinchot) tonnage tax. The county taxes jumped to $4,800,000, or an increase of 170 percent, while the ambitious municipal authorities increased their grab to something over $15,000,000, or nearly 440 percent. That is, in just 11 years, the taxes paid (and this does not include Federal taxes) by the anthracite companies jumped from $5,660,000 to over $25,000,000. Is it to be wondered that the courts have, in the recent decisions of Justice Frazer and your own revered Judge Fuller, loosed to some extent the hold of the tax gatherer?

The total state, county, and municipal taxes in 1913 amounted to 8 cents a ton; they now amount to about 35 cents a ton on the total production, or nearly 60 cents a ton on the domestic sizes.

Costs of supplies and overhead have also added to the burdens the anthracite industry is carrying, though not to the same extent as have the increases in the cost of labor and taxes. The bill for supplies and replacement of machinery at the present time amounts to approximately $75,000,000, most of which is paid to the manufacturing industries in the region. Practically without exception the anthracite-producing companies believe in the encouragement of home industry and all of the supplies that can be furnished by concerns in the region are purchased in the region. Altogether, through wages, supplies and local taxes, the amount of money coming into the anthracite communities every year reaches, and, in fact, somewhat exceeds the tidy sum of $400,000,000.

The cities of Detroit and Flint in Michigan do not knock the automobile industry; the city of Akron, Ohio, is proud of its tire industry; Fall River, Mass., and the other textile manufacturing centers of New England are friendly to their special industries; Brockton does not attack its shoemakers. One could name thousands of communities throughout the entire length and breadth of the country that foster and protect the industries that make for their prosperity and well being. Why, may it not be asked, should the anthracite region exhibit a notable exception to such a custom and state of mind? But yet, through the something over a century of the anthracite industry's history there has been little, if any, cooperation and helpfulness toward the industry. On the contrary, has there not been persistently and consistently manifested a disposition the reverse of helpfulness, as evinced in the fixing of taxation and, in times of labor trouble, by the piling of burden upon burden on the industry, apparently on the theory that it could stand anything and that the region would get the benefit of it indirectly, anyway?

It is gratifying also to contemplate the change that has taken place in the attitude of the local press, previously almost uniformly assuming an attitude adverse to the industry, espousing the cause of its enemies, the tax officials, the labor leaders and the politicians, who were seeking to place further burdens upon it, and giving little thought to the effect that such an attitude must eventually have upon the industry and the region. Now, we are able to say, and thankfully, that this attitude of the regional press has changed, and that it is today almost as uniformly helpful and constructive as it has in the past been hostile and destructive. It is a happy change and if maintained augurs well.

It is not to be expected that the press shall accept without question the view of the anthracite operators on contentious matters, such as the adjustment of wages when the agreements expire, but the operators feel, and they have the right to feel, that they should have the support of the press and the public when they are in the right and are contending for the best interests of the industry, the anthracite-consuming public, and the anthracite region. They are entitled to ask, and to have, your support, on the proposition that reason and not force shall govern in the settlement of these wage controversies, and that when agreements can not be reached by negotiation the determination of such a complicated matter should not be left to industrial warfare but to fair and judicial arbitration. Is it an unreasonable request?

There is no doubt that the product of this region—anthracite—is meeting with a strong sales resistance, the chief reason for which has been the interruption to a steady supply caused by the strikes and suspensions with which the anthracite industry has been accursed. Naturally, when the anthracite-consuming public could not, as in the winter of 1925-26, obtain its preferred fuel, it took what it could (*Continued on page* 710)

*Director, Anthracite Bureau of Information, Philadelphia, Pa. Extracts from address before the Rotary Club, Wilkes-Barre, Pa.

Kennedy Mine, Jackson, Calif.

ACTIVITIES OF THE CALIFORNIA METAL AND MINERAL PRODUCERS' ASSOCIATION

THE problems of the mine operators of California are directed through the California Metal and Mineral Producers' Association. These are legislative measures, enforcement of the Ore Buyer's Act, Workmen's Compensation, and Accident Prevention.

Legislative matters are handled by the secretary-treasurer of the association in cooperation with the board of directors. During the last session of the California Legislature, 1927, no bills were passed which were detrimental to the mining industry. Amendments to the Ore Buyer's Act were passed and approved by the governor which strengthened said act by providing enforcement features lacking in the original measure. A bill was passed and approved by the governor providing for the creation of a department of natural resources, this department to be administered by a director. The work of this department will be divided into four divisions, to be known as the division of mines and mining, division of forestry, division of parks, and division of fish and game. This department is directly connected with the mining industry as the enforcement of the Ore Buyer's Act is under the supervision of the state mineralogist. The enforcement of the Ore Buyer's Act has been of aid to the industry, as it has been a curb on "high-grading," a number of convictions have been secured and gold recovered. The amendments recently enacted will greatly strengthen the act, which is said to be the best so far adopted by any of the states.

A bill providing for an increase in maximum weekly earnings from $32.05 to $37.46 and maximum death benefits from $5,000 to $5,999.76 was "tabled" by the insurance committee after public hearing. It is plain that this bill would have created an additional expense to the mining industry.

Workmen's compensation is a problem which has required study, and one which has been a source of worry to operators, due to the increase in rates and the class of labor employed in most of the mines. It is difficult at times to determine whether or not an injured employe is able to resume work; sprained back has been used by some as a means of avoiding resumption of work.

Accident Prevention.—Operators are endeavoring to reduce the number of accidents by means of proper supervision, an appeal to employes by means of safety rallies, and the elimination of any place of employment which may offer a hazard. Mexican labor is a problem, for it is difficult to instill in them a spirit of self-preservation or the fulfillment of safety regulations promulgated either by the state or the operators. The California Metal and Mineral Producers' Association is endeavoring to do its part by employing a mine safety engineer to assist the members in an effort to reduce accidents. This engineer, G. Chester Brown, was formerly chief mine inspector of the California Industrial Accident Commission for a number of years, and is thoroughly conversant with mining conditions in California.

THE ANTHRACITE INDUSTRY

(*Continued from page* 709)

get in the way of substitutes, and the purveyors of those substitutes have not failed to take advantage of the situation. Bituminous coal, coke, and oil have undoubtedly secured each for itself a foothold in our market, and they not only are not going to release them without a struggle but are going to endeavor, are endeavoring, further to dethrone anthracite.

Another cause for the sales resistance to anthracite is, of course, the higher prices which have been imposed upon it by the increasing costs. And yet anthracite has not advanced in price corresponding to the increase in the prices of many other commodities, nor in proportion to the increase in the cost of production. I have shown you how since 1913 labor cost has trebled and taxes quintupled. The average value of the anthracite production of 1913 was $2.39 per gross ton; in 1925 it was $5.94, or not quite two and one-half times what it was in 1913. In the face of present costs any reduction in the price at the mines would mean bankruptcy to a material number of producing interests.

In 1924, which was a normal year in anthracite production, the Secretary of the Treasury in his letter to the United States Senate, replying to the La Follette resolution (Senate Document No. 48, 69th Congress, 1st session) shows that of 139 operating companies 47 paid Federal income taxes, whereas 92 either made no profit or actually lost money. The profitable companies showed a little over $28,000,000 of net income; the losses amounted to $7,000,000, so that the net profits for the industry were between $21,000,000 and $22,000,000, which on a commercial production of 71,689,000 tons means about 30 cents a ton, and on the capital invested of approximately $600,000,000 it means a return of less than 4 percent. The report of the Secretary is in close agreement with and confirms the results of investigations by the Federal Trade Commission and the United States Coal Commission, which extended over a period of 10 years from 1913 to 1923. These investigations showed that the average margin on the anthracite production for the decade covered by them was 41 cents a ton, from which had to be deducted 9 cents a ton for Federal taxes and interest, leaving 32 cents as representing average profits over a 10-year period. These are the earnings on the money invested in your industry, which your recent governor has upon more than one occasion termed a hard-boiled monopoly.

The present situation confirms the contention of the anthracite operators that interruptions of supply and mounting costs are hampering the industry. We must join forces in the effort to upbuild it, and the industry welcomes the help of you business men, of your banking institutions, of the local press, of the mine workers and other labor, and of the public in regaining its markets and in putting anthracite on a basis profitable, not only to itself but to all the interests in the 500 square miles of anthracite-producing territory. The glad hand of cooperation, as evinced by this meeting, is joyfully grasped and, as some wise guy has paraphrased an old saw, let us—

"Early to bed, early to rise
Work like hell and advertise,
ANTHRACITE."

MINING PROBLEMS IN ARIZONA

Problems Solved By Improved Concentrating Methods—Copper Recovery Highest In History—Large Increase In Arizona's Production Since 1909 Is In Copper Derived From Low Grade Ores —Freight Rates And Taxation Matters For Attention

By W. B. GOHRING*

THERE is no question but that the outstanding development in copper in recent years, in Arizona as well as in other producing centers, is the improvement in the processes for recovering the metal from very low-grade ores.

The continuing low price for copper has forced the operators to scrutinize every branch of the operations for opportunities to economize, or to improve their processes and practices, and as a result it is probable that Arizona copper operations are on a higher plane of efficiency than ever in their history.

It is in the milling end, however, that the greatest changes have been made in practice.

I do not think it any exaggeration to say that a large percentage, perhaps one-third of the present copper output, could not be produced at a profit, on copper prices that have prevailed since the war, if the operators were still dependent on the mill practice, and the recoveries and costs resulting from the best concentrating practices in use before and during the war.

I estimate that 65 percent of Arizona's copper production comes from low-grade or concentrating ores, and that probably 25 percent comes from ores averaging approximately 1.0 percent copper. The gross value of metals recovered on this last ore will not exceed $2 per ton on recent copper prices, and it is obvious that there can be no great margin of profit left from this after covering mining, milling, smelting, freight and general costs.

The result is that the utmost economy and efficiency is necessary, and in the mills particularly the technical and operating staffs are constantly experimenting with new flotation reagents and general research in the attempt to cut another fraction off the costs or to increase the metal recovery another percent.

Another effect of the development of these processes for recovering values from very low-grade copper ores is in the enormous extension of Arizona's ore reserves. Material that was not called ore a few years ago is now included in the ore reserve tonnage in many mines, and the figures show that many years have been added to Arizona's copper life through these improved milling practices.

The importance of low copper content ore to Arizona is shown in the fact that in 1909, about the last year when all of our Arizona copper came from high-grade or direct smelting ores, the total production for the state was 256,000,000 pounds, which is almost exactly what we made last year from direct smelting ores. In other words, the entire increase to the state's present production of over 700,000,000 pounds is in copper derived from low-grade ores. It is probable that as much copper has been rendered available and added to Arizona's all-time production by recently improved mill practice, as was added to the supply available from direct smelting ores by the original development of gravity concentration mill practice.

While the necessity for the utmost economy, enforced upon the operators by the condition of the copper market, has certainly resulted in increased efficiencies in all departments, the close scrutiny and detailed study of all outgo or cost items which has taken place to bring about this result has also served to emphasize the importance of cost items over which they have no direct control, such as freight rates and taxes.

The copper companies of Arizona pay the railroads a freight bill of from $18,000,000 to $20,000,000 per year, or about 2½ cents for each pound of copper produced. The freight on certain of the major supplies is as much as, or more than, the price of the commodity. On fuel oil imported for the mines, smelters, and mills alone the freight bill in 1926 was over $4,731,000.

It has been felt by some of the operators that certain freight rates were unjust, but the present policy of the operators is to attempt rate adjustments by direct appeal to the railroads rather than by an attack on the rates through the Interstate Commerce Commission.

The mines of Arizona in the past 10 years have been valued for tax purposes at from 58 percent to 42 percent of the total state valuation. As all property in Arizona is taxed on a straight ad valorem basis, this means that the mines are taxed that percentage of the state expenditures. During the present year the mines are assessed at 43 percent of the total state value. The increasing state expenditures are accordingly a matter of concern to the mining companies.

Ransome, U. S. Geological Survey

Miami Plant; at top, Smelter of Magma Copper Co.

*Secretary, Arizona Chapter, The American Mining Congress.

REPORTS ON THE MECHANIZATION SURVEY

Four Scraper Operations On Long Face Mining In Seams From Four To Twelve Feet High—Methods Of Roof Support—Large And Small Type Scrapers—Faces From Seventy-Five To Five Hundred Feet Long

By G. B. SOUTHWARD

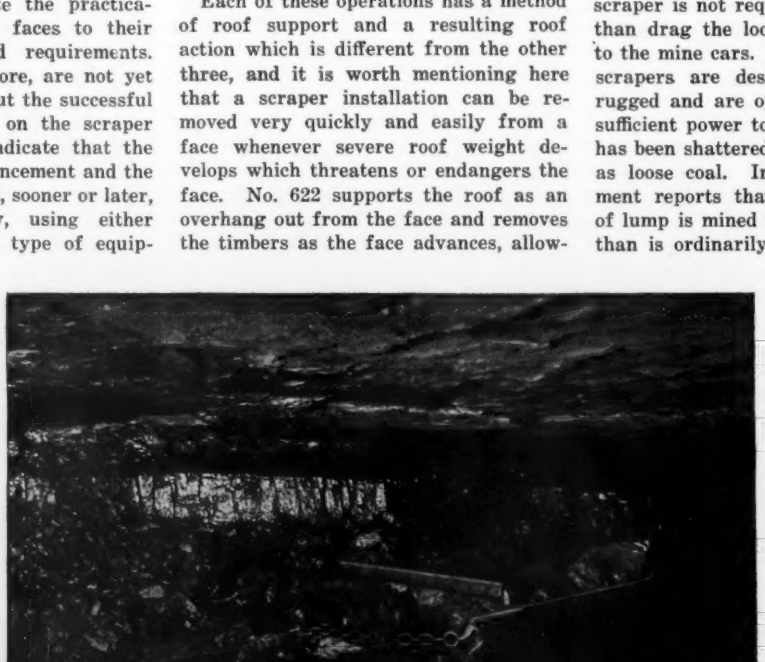
AS SOME of the more recent developments in scraper mining have been made in long face work, the reports—Nos. 622, 113, 67, 28—accompanying this article, describe four scraper operations applied to modified long face mining, and are submitted to illustrate the successful operation of scrapers in bituminous coal with the added feature of showing some interesting mining systems developed for their use. These are in seams varying from 4 to 12 feet in height, with impurities as high as 12 percent, in coal ranging from a rather soft to a hard blocky structure and with covers varying from 100 to 1,000 feet.

In these operations the scrapers are confined to the face work only and the entry development and the chain pillar recovery is by hand or by some other method of loading. This does not necessarily indicate that scrapers are unsuitable for narrow work or chain pillar mining but since these operations were primarily designed and equipped for face scraper mining, the development so far has been to demonstrate the practicability of adapting long faces to their physical conditions and requirements. These operations, therefore, are not yet completely mechanized but the successful results so far attained on the scraper faces are such as to indicate that the coal from the entry advancement and the chain pillar recovery will, sooner or later, be loaded mechanically, using either scrapers or some other type of equipment to supplement the face operations and make a completely mechanized mining system. This is illustrated in the description of operation No. 67 where the entry development is by a shaker loader, and this method of entry driving will be described in some later report.

In these four systems shown, the panels are developed ahead of the face operation and while all are using some form of long face mining, each plan differs in some respect from the other three so that these reports show four separate and distinct scraper mining systems. No. 622 is a continuous retreating longwall face, 300 feet long. No. 113 shows an application of the "Y" system, in which two faces each 75 feet long are angled in toward each other to form a "V" shaped area which mines from the panel limit in toward the haulage entry. Both of these plans are designed to recover 100 percent of the coal, excluding the chain pillars. No. 67 develops the panel into rectangular blocks which are worked advancing by faces 500 feet long and is designed to recover by scraper mining two-thirds of the coal in these blocks, leaving the remaining pillar to be recovered later by a conveyor with a shaker shovel. No. 28 is developed and worked somewhat similarly to No. 67 except that the faces are 300 feet long and the plan is designed to recover as much of the developed block as the roof weight will permit, leaving the remainder of the coal unmined in a thin pillar.

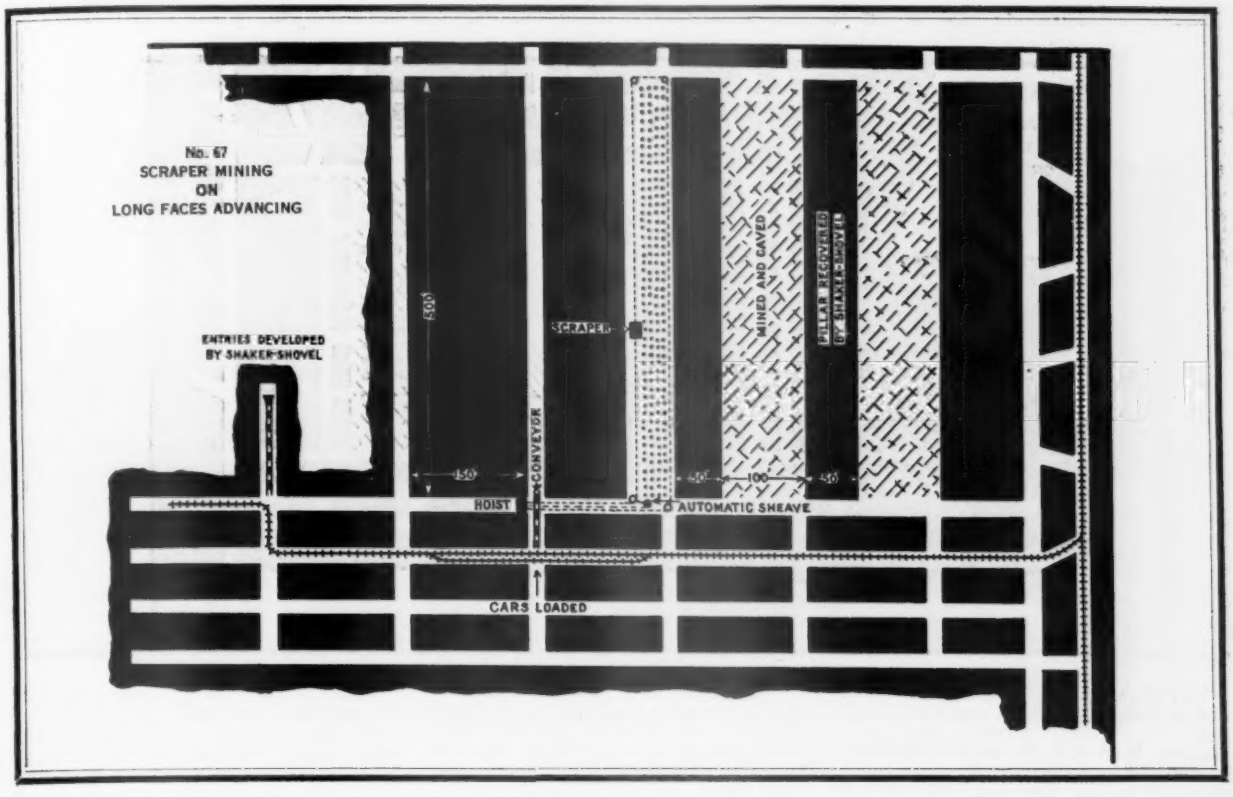
Each of these operations has a method of roof support and a resulting roof action which is different from the other three, and it is worth mentioning here that a scraper installation can be removed very quickly and easily from a face whenever severe roof weight develops which threatens or endangers the face. No. 622 supports the roof as an overhang out from the face and removes the timbers as the face advances, allowing the top to cave behind the face supports. In No. 113 the roof over the "V" shaped area acts as a beam supported at each end by the coal along the faces, and timbers are set and maintained in this area to hold the top. In the mined area out beyond the end of the faces the timbers are crushed by the roof weight and the top caves. In No. 67, it has been found that the faces can mine out an area approximately 100 feet wide before severe roof weight develops and in this operation the top is held until the faces have advanced 100 feet, when the timbers are removed and the roof caves. In No. 28, no timbers are recovered and the faces advance as far as the roof weight will permit and are discontinued when the timbers begin to crush.

Little, if any, slate picking is done along the faces and where the seam has a parting which has to be separated from the coal, the cleaning is done at the tipple either by hand or by a mechanical coal preparation plant. With the smaller types of scrapers, as shown in Nos. 113 and 622, it is the practice to have the coal fairly well shot down so that the scraper is not required to do much more than drag the loose coal from the face to the mine cars. In Nos. 28 and 67 the scrapers are designed and built very rugged and are operated by hoists with sufficient power to dig out a face, which has been shattered but not brought down as loose coal. In No. 67 the management reports that a higher percentage of lump is mined from the scraper faces than is ordinarily produced from rooms and pillars with hand mining but in the other three operations no particular effort is made to produce a high percentage of large sizes.



The number of men employed and the tonnage produced during a shift varies considerably between these operations but these factors are governed by local conditions and requirements and it should be stated here that all of these operations are reported by their managements as mining economically and successfully.

Report No. 67



PHYSICAL CONDITIONS: The seam averages over 8 ft. in height, being at times as high as 12 ft. The coal is of fairly hard structure and a bone parting occurs occasionally with a thickness of as much as 3 inches. About 2 ft. of top coal is left along the entries but the entire seam is mined along the faces. Above the seam there is a strata of slate 2 ft. in thickness with overlying sandy shale. The top generally stands well and can be supported without a great amount of timber. Hard shale bottom. Seam pitches from 5 to 12 percent. Cover 100 to 500 ft. Closed lights. Entries rock dusted and sprinkling is used on the machine cutterbar.

MINING SYSTEM: Long face advancing with scraper loading on the faces and the entry development by conveyor with shaker loader. A panel 500 ft. wide is developed by four headings with single entries driven off at 150-ft. intervals at right angles through to the air course in the adjoining panel. This develops the panel into blocks 140 ft. wide by 500 ft. long and each block is mined by a face 500 ft. long which starts at the single entry and mines forward for a distance of approximately 100 ft.—supporting the roof on timbers over the mined area. When this point is reached the face is discontinued and the timbers are removed and the remaining pillar—approximately 50-ft. thick—is later recovered by splits and cross cuts worked with a conveyor and shaker loader. Only one face is worked at a time in a panel.

MECHANICAL OPERATION: The scraper has a capacity of 3 tons and is operated by a 3-drum electric rope hoist which is set in the heading and drags the scraper along the face where it collects the coal and then around the corner at the end of the face and down the heading to where it discharges onto a short conveyor which is laid through a cross cut and loads into mine cars on the haulway. The scraper is operated by head and tail ropes with an automatic sheave on the heading at the end of the face to change the direction of the scraper travel when turning the corner. When mining on a block is started, the rope hoist and the cross conveyor are set 150 ft. down from the end of the face and remain at that location until the face has advanced to within 50 ft. and completed mining that block. The tail rope sheaves remain set but the head rope sheaves and automatic sheave are moved forward after each face cut is completed. Mine cars of 2¼-ton capacity are placed in 11-car trips at the conveyor discharge by a gathering locomotive which also serves the entry development. A siding or passing track is provided opposite the conveyor loading point and 40-lb. steel rail on 36-in. gauge is used along the haulway.

The faces are undercut by machine with a 7½-ft. bar, drilled by an electric hand drill and shot with permissible explosive and electric firing. Shots are spaced about 10 ft. apart and shatter the coal in a standing face which is dug out by the scraper.

TIMBERING AND ROOF ACTION: Timbers 8 in. in diameter are set on 4-ft. centers with either one or two rows to each cut as roof conditions determine. These are left in as the face advances and are removed when the face has completed mining on a block. After timbers are removed the top caves and the 50-ft. block left unmined between two adjacent faces can later be recovered more or less completely. Experience has shown that under the conditions existing at this mine an area 500 ft. long by 100 ft. wide can generally be mined before any severe roof weight is encountered and a 100 percent timber recovery is reported.

OPERATING CREW: The loading operation is performed on the day shift with the cutting, drilling and shooting at night, both shifts being eight hours long. The day crew consists of eight men—1 foreman, 1 hoist operator, 1 signal man, 1 faceman, 2 timbermen and 2 men on the cross conveyor who load and trim the cars. The night crew consists of 6 men; 2 cutting machine men, 2 drillers, who also load and fire the shots, and 2 timbermen. This makes a total of 14 men on the regular crew and an average of about 300 tons is produced during each loading shift.

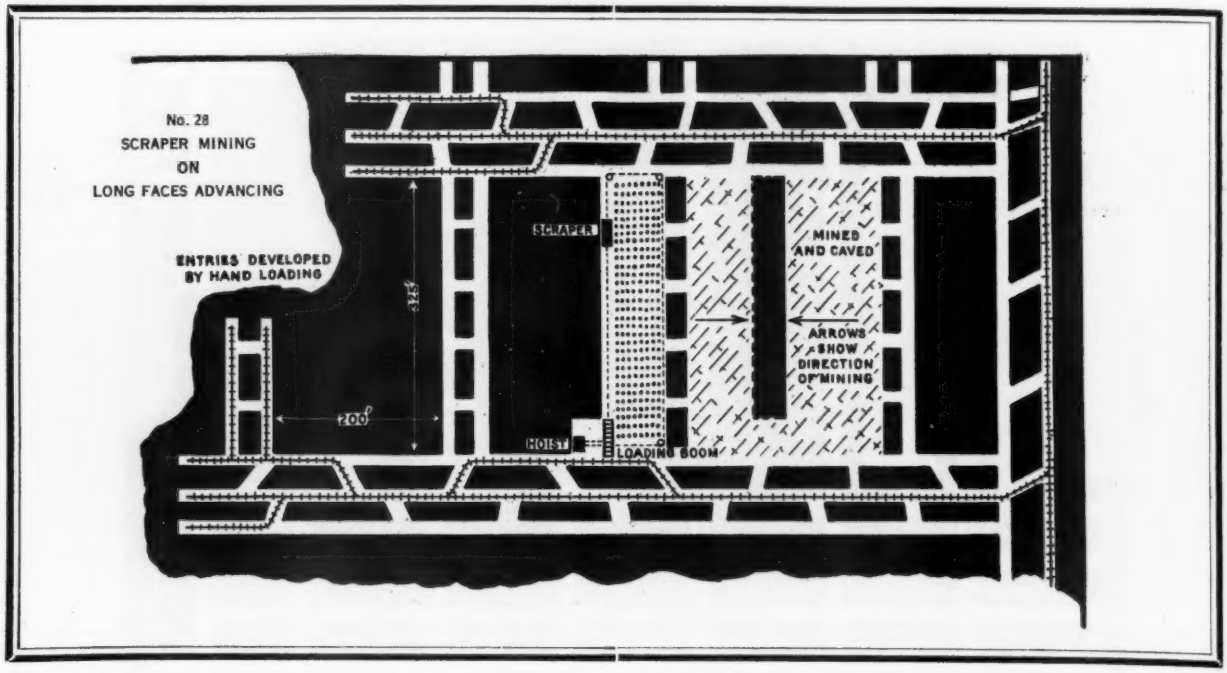
When the face has completed mining on a block additional labor is required to move the hoist and the cross conveyor and reset them in the next location ahead. This work is usually performed over a week-end so as not to delay the loading operation.

EQUIPMENT: Each face operation uses one scraper and hoist complete, 1 flight conveyor 50 ft. long, 1 cutting machine, 1 electric drill, and 1 gathering locomotive.

PREPARATION: Run-of-mine only is produced at this operation and no screening or slate picking is done at the tipple.

CONCLUSION: This operation has been in use for over a year and a half and is considered by the management as satisfactory and has effected marked economies over their hand mining operations.

Report No. 28



PHYSICAL CONDITIONS: The seam varies from 6 to 8 ft.—medium hard coal—with a parting near the center varying from 1 to 8 in. in thickness. A draw slate is frequently encountered up to 6 in. in thickness with strong slate top above. Hard fire clay bottom. The seam is generally flat but some rolls are encountered. Cover 100 ft. Open lights.

MINING SYSTEM: Long face advancing with scraper loaders on the faces and entry development by hand-loading in mine cars. Panels 325 ft. wide are developed by triple entries on both sides with double entries driven through at 200-ft intervals, blocking the coal into areas 200 ft. wide by 325 ft. long. These blocks are mined by long faces slabbing along the 325-ft. side. A face starts at the double entry and mines in toward the center of the block until an area 100 ft. wide has been mined out. The face is then discontinued and the scraper is moved ahead to the double entry at the opposite side of the block where a new face is started, which mines back toward the area just completed and recovers as much of the remaining 100-ft. block as the roof weight will permit. When this point is reached, the scraper is removed and set up in the next developed block ahead and the operation is repeated.

MECHANICAL OPERATION: The scraper has a capacity of 3½ tons and is moved by head and tail ropes which are operated by a double drum electric hoist which is set on the haulageway. The scraper is pulled along the face where it collects the coal and down to the haulway where it empties onto a loading conveyor which discharges into mine cars. The loading conveyor is about 40 feet long and is set on the haulageway at the end of the face, in line with and parallel to the face. Consequently, before the face operation can be started on a block the haulway must be widened to 40 feet so as to provide the clearance required for the conveyor. This is done by slabbing the block to be mined 40 feet back from and parallel to the haulway which reduces the actual length of the face from 325 to 285 feet. The scraper hoist is set about 100 feet from the end of the face and remains at that location until mining on a block is completed. The loading conveyor is moved forward after every second cut so as to be kept approximately in line with the face.

Mine cars of 2-ton capacity are delivered by a gathering locomotive to the loading conveyor in trips of from 10 to 15 cars and are moved past the discharge point by a small rope hoist while loading in a solid trip.

The face coal is machine undercut 7 ft., drilled with an electric hand-drill and shot with permissible explosive. Two rows of shots are made; a bottom row spaced about 8 ft. apart and a top row spaced about 10 ft. apart, with from two to three sticks of powder in each shot. The shooting is not intended to bring the cut down in loose coal as the scraper is powerful and will dig out a standing face which has been shattered by the explosive.

TIMBERING AND ROOF CONTROL: Two rows of posts, parallel to the face, are set after each cut, the first row being about 7 ft. from the face, using timbers from 6 to 10 in. in diameter, set on from 3 to 6-ft. centers. These are not recovered but are left in place until crushed by the weight of the roof strata over the mined area. No attempt is made to keep the face open during a fall; the roof is held on timbers while the face is advancing and when a fall is expected the equipment is removed and the face abandoned. The strong top and light cover permit fairly large areas to be mined before caving occurs, and while some coal is left unmined in the pillars which are abandoned the management reports that a satisfactory recovery is made.

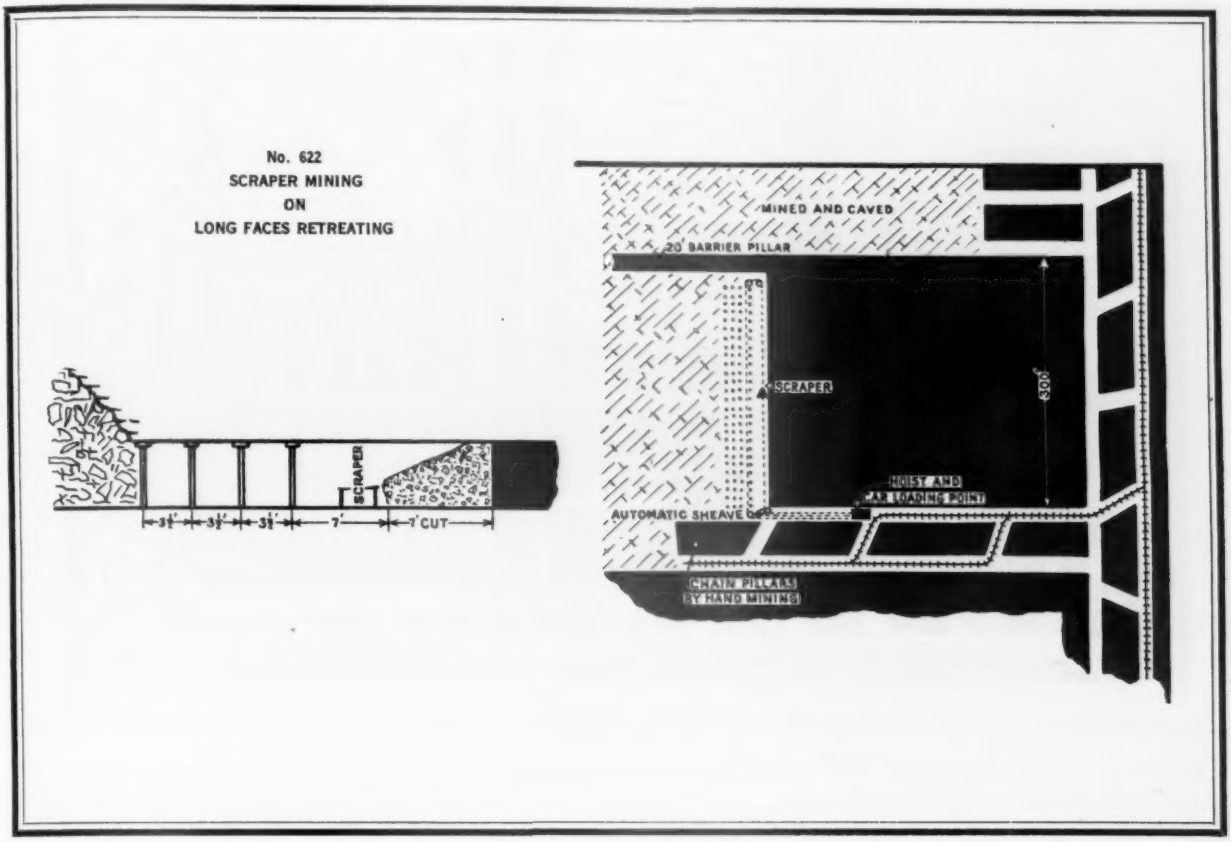
OPERATING CREW: Loading is done on the day shift and cutting, drilling, timbering and other dead work on the night shift. The day crew has 2 facemen to guide the scraper and remove slate; 1 hoist operator, 1 loading conveyor operator, and 1 signal man. The night crew has 2 timbermen, 2 machine cutters, and 2 drillers who also fire the shots. This makes a regular crew of 11 men, and in addition 3 men are used to move forward the head frame and loading conveyor after every second face cut. Extra labor is also required periodically when the face mining is completed on a block to move and reset the equipment at a new location. A face at a full length of 285 ft. will produce about 450 tons with a 7-ft. undercut and the average amount loaded by the day shift varies according to the conditions encountered. A record taken over one month showed an average daily production of 266 tons.

EQUIPMENT: Each face operation uses one scraper installation complete with loading boom and electric hoist, one cutting machine, one electric hand drill, one gathering locomotive and one small rope hoist for moving cars at the loading point.

PREPARATION: The management reports that a higher percentage of lump coal is obtained from the faces than is ordinarily had in hand mining. Some slate is removed inside the mine, but the coal from the face mining has a higher percentage of impurities than from hand mining, and a few additional slate pickers are required on the tipple.

CONCLUSION: This operation has been in use for over three years and is reported as satisfactory and successful by the management. About 33 percent of the present mine production is by this system.

Report No. 622



PHYSICAL CONDITIONS: Seam is about 5 ft. high—of medium hard structure coal with a bone parting about 12 in. below the top. The full height is taken in the entries but along the faces the bone parting and the coal above is left up. The top above the seam is a slate which requires some timbering in the headings and the bone parting makes a better roof for the face work. Very soft slate bottom which heaves or raises under pressure and makes timbering difficult. Seam is generally level. Cover 800 to 1,000 ft. Closed lights—sprinkling and rock dusting.

MINING SYSTEM: Longwall or long face retreating with scrapers on the faces. Entry development by hand loading into mine cars. A panel 300 ft. wide is developed by a pair of entries and a face 280 ft. long, at right angles to the entries, is mined retreating from the panel limit down to the main barrier. A small barrier pillar 20 ft. thick is left unmined at the end of the face next to the gob in the preceding panel and the chain pillar along the entry is recovered by hand loading into mine cars.

MECHANICAL OPERATION: A scraper loader with a capacity of 1,200 lbs. is used along the face and is operated by a three drum electric rope hoist which is set in the haulage entry. The hoist drags the scraper along the face—where it collects the coal—then around the corner of the pillar at the end of the face and down the haulage entry to the mine car loading point, using head and tail ropes for travel and an automatic sheave to change the direction at the corner of the pillar. The hoist is set at a maximum distance of 150 ft. from the end of the face and remains at each set until the face has mined to within 50 ft. when it is moved ahead and reset.

Mine cars of 1½-ton capacity are placed on the tail track above the scraper dumping point in 10-car trips by a gathering locomotive and are dropped in for loading one at a time by hand. Track of 25-lb. steel on 36-in. gauge is used along the haulway.

The face is undercut by machine with a 7-ft. bar, is drilled by an electric hand drill and shot with permissible explosive and electric firing. Shots are placed about 7 ft. apart with two sticks of powder in each.

TIMBERING AND ROOF ACTION: Two rows of timbers from 4 to 6 in. in diameter are set after each cut—spaced 3 ft. apart. Four rows are maintained; the first row is set 7 ft. from the face before the coal is shot and the fourth row is about 18 ft. from the face, supporting the roof as an overhang for this distance and allowing it to cave beyond. The back lines of timbers are removed after each cut and the roof falls are fairly satisfactory but are not always complete and at times the weight comes forward onto the timbers. An average timber recovery of about 50 percent is reported.

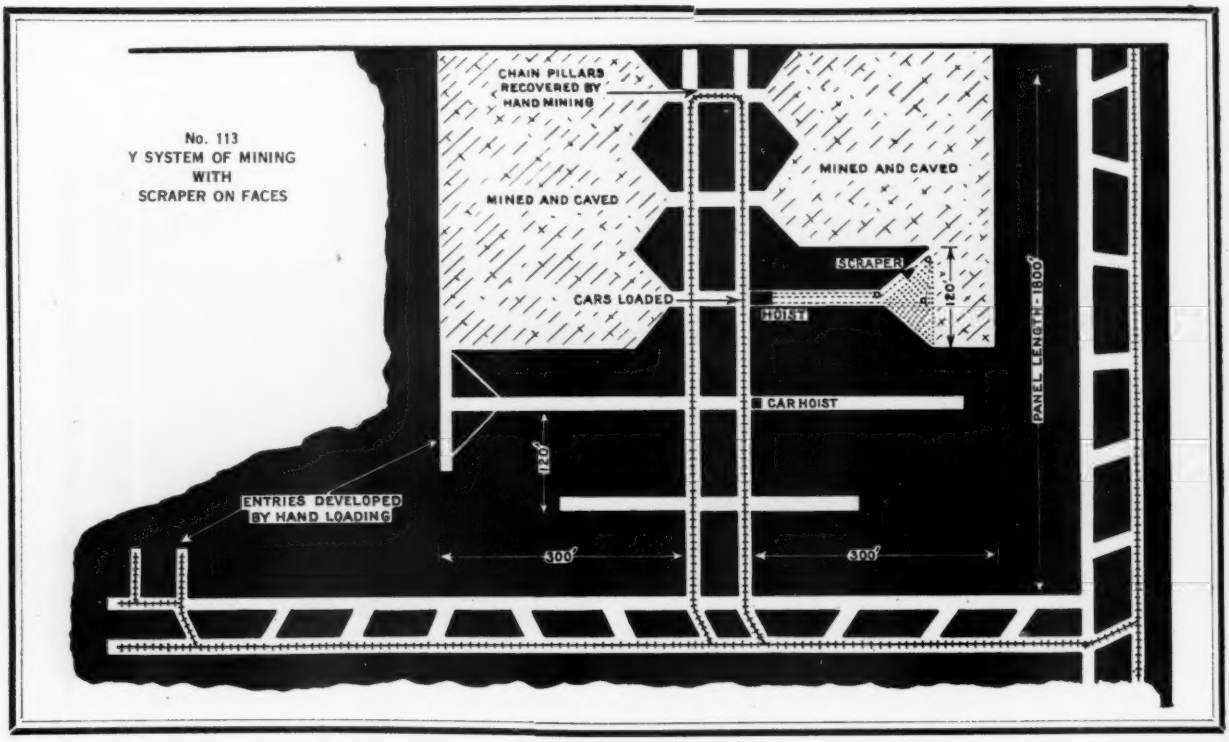
OPERATING CREW: All work is done on a day shift of 8 hours by a regular crew of 5 men—1 hoist operator who also trims and drops the cars, 2 facemen, 1 timberman and a foreman who works where needed. A face cut produces from 250 to 275 tons and is loaded out once every 5 or 6 days—averaging from 50 to 60 tons loading per day. After a clean-up this same crew does the cutting, drilling, timbering, etc., for the next cut, usually taking one shift for these operations. A gathering locomotive crew of two men place cars for the scraper face and also serve other workings near by.

PREPARATION: No slate picking is done inside the mine and the management reports that the coal from the faces requires some additional picking at the tipple as compared with coal from hand mining. Shaking screens are used but no particular effort is made at this operation to secure a large percentage of lump sizes.

EQUIPMENT: Each face operation uses one scraper installation complete with electric hoist, one cutting machine and one electric hand drill. The gathering locomotive which serves this operation is also used for other work near by.

CONCLUSION: This equipment and this method of mining have been in use for about two years and the management considers it to be on a practicable successful operating basis in competition with their hand loading under similar conditions. The roof action along the faces is not yet entirely satisfactory but it is expected that the difficulties thus far encountered will be overcome in the future.

Report No. 113



PHYSICAL CONDITIONS: The seam averages slightly under 4 ft. in height—rather soft coal with 6 in. of impurities. The top is a stratified shale which stands well in the workings and breaks in the mined areas. Medium soft fire clay bottom. The seam is generally flat with frequent rolls of from 10 to 20 percent grade. Cover 300 ft. Non-gaseous. Open lights. Rock dusting. Bottom is taken for heighth along the haulways.

MINING SYSTEM: Y system retreating with scraper loaders on the faces loading into mine cars. Entry development and chain pillar recovery by hand loading into mine cars.

Panels 650 ft. wide by 1,800 ft. long are developed to the barrier limit by a pair of haulage entries in the center with single entries on 120-ft. centers driven to the right and left 300 ft. long. A pair of faces, each face 75 ft. long, is turned to the right and left off each single entry, the faces angling in toward the entry so as to form the 2 flanks of a Y with a central angle of 90 degrees. Slab cuts are taken along the faces, keeping the central angle constant and mining retreating from the panel limit in toward the pair of haulage entries in the center. Only one pair of faces is worked at a time and mine down to the haulway before the next pair is started.

MECHANICAL OPERATION: One scraper loader with a capacity of 1,500 pounds is used for a pair of faces and drags the coal from along the face down through the single entry and discharges into mine cars on the haulway. A three-drum electric rope hoist moves the scraper at a speed of 300 feet per minute by head and tail ropes and also operates an automatic sheave set in the throat of the Y which changes the direction of the scraper travel from the face down through the entry. The hoist remains set at the intersection of the single entry and the haulway until the faces have mined down to that point.

Mine cars of 1.8-ton capacity are moved at the scraper discharge point while loading in 15 car trips by a remote control rope hoist. One gathering locomotive delivers cars to the scraper operation and hauls coal and supplies for other workings near by. Track on the haulway is laid with 40-lb. steel rail on 36-in. gauge.

DRILLING AND SHOOTING: The faces are machine undercut 6 ft.; drilled by electric hand drill and shot with permissible explosive with electric firing. Shots are spaced 8 ft. along the face with 1½ sticks per shot, producing from 15 to 18 tons of coal per pound of explosive. The coal is well shattered and is picked down by hand to some extent to facilitate the scraper operation.

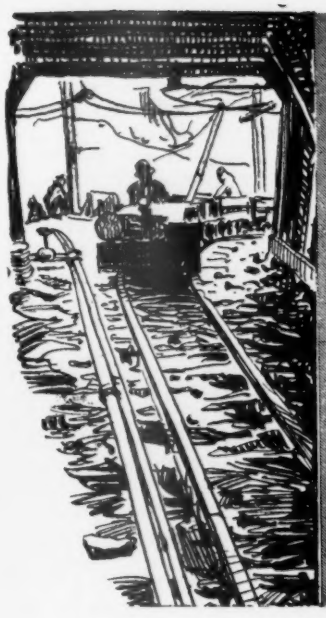
TIMBERING AND ROOF ACTION: A row of posts, 6 in. diameter, are set on 6-ft. centers parallel to the face and about 6 ft. from the face after each cut is loaded out. These timbers are left standing and support the roof along the faces and in the throat of the Y between the faces. As the mining advances, roof falls occur in the mined area behind the faces, but when a fall is expected a "breaker" row of timbers is set across the room from the end of one face to the end of the other, and the roof generally breaks on this line, leaving the faces open. No timbers are recovered and no attempt is made to cause a fall; the timbers remain in place until crushed by the roof weight.

OPERATING CREW: Loading, timbering and drilling is done on the day shift with the cutting and shooting on the night shift. A regular crew has a foreman, 2 facemen, who pick down any hanging coal; 1 timberman; 1 scraper-hoist operator; and 1 car trimmer. The night crew has 2 men who do the cutting, drilling and shooting. This makes a regular crew of 7 men in addition to a gathering locomotive crew of 2 men who also serve the development work. Each face will produce about 70 tons of coal per cut, or a total of 140 tons from the pair of faces, which are usually loaded out in an 8-hour shift. Besides the regular work, extra men are employed part of a shift to move the scraper installation to the adjoining side after a block is mined out. This occurs about once a month.

EQUIPMENT: One face operation uses one scraper with electric hoist, one cutting machine, one electric hand drill, and one rope hoist for car moving.

PREPARATION: The coal has a soft friable structure, and there is no particular desire nor effort made to produce lump coal. Some slate picking is done inside, but a very modern air-cleaning plant has been installed on the surface.

CONCLUSION: This operation has been in experimental use for nearly a year and is considered to have demonstrated that this system is practicable and successful. While the results thus far obtained indicate a very attractive cost saving as compared with hand mining and several other mechanical systems experimented with, it is too early to make practical comparison of savings. The work, however, is indicative of very material advantages as to closer supervision, concentration of production, better roof control and decreased repairs and maintenance costs. It is the opinion of the management, however, that this system of mining must be supplemented with an efficient mechanical coal preparation plant to insure a high-grade commercial product.



COAL

PRACTICAL OPERATING MEN'S DEPARTMENT

NEWELL G. ALFORD, Editor

Practical Operating Problems of the Coal Mining Industry

ENTRY DRIVING WITH MECHANICAL LOADERS AT C. & O. MINES

Mechanical Loaders Installed To Increase Speed Of Entry Development—In Successful Operation For More Than A Year—Additional Machines Installed In Other Mines—Lower Cost By Mechanical Loading Than By Hand Loading

By HERBERT B. HUSBAND *

NOTHING in this sketch should be taken as an attempt to advertise the type loaders in use at our fuel mines, for it has been proved by experience that the success of any type loader depends on the judgment used in the selection of the machine best suited to the conditions under which it must work and on the calibre of crew used to operate it. From the fact that the shovel type loader works successfully in our mines, it should not be assumed that this type shovel will work successfully even in a neighboring mine. It is for this reason that the name of the loader is not being mentioned in this article. Considerable thought and study should be given to the type of loader selected if one is to accomplish profitable results. The loaders were introduced in our mines not as an experiment but for the very definite purpose of driving entries, and the shovel type loader was selected after nearly a year of careful study and observation of all type machines on the market. No great results in cost savings were anticipated, neither were the machines expected to load marvelous tonnages, but did expect to drive 30 feet of entry or better in eight hours, and we did.

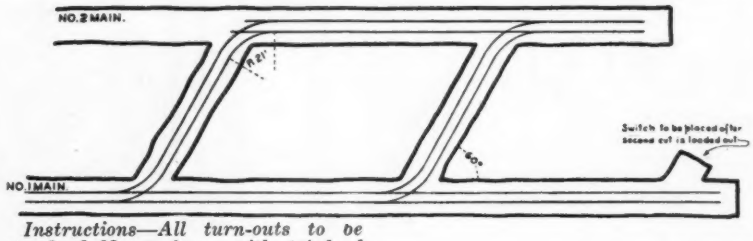
The first loader was put into service in March, 1926, at Sarita No. 2 mine. This mine was opened to take the place of Sarita No. 1, which was rapidly being depleted. It was found after nearly two years of hand loading methods that we could not possibly develop the mine fast enough to offset the falling tonnage in the old mine. Something had to be done, so mechanical loading was started.

The next thing for consideration after the type loader had been selected was the organization to operate it, for with a mechanical loader as well as with any other piece of machinery the life and efficiency depends largely on the care given it. The mechanical loader operator, in addition to being a skilled mechanic, must also be a practical miner and thoroughly familiar with conditions at the working face. He must be a leader and able to handle the crew of men assigned to the loader. Under the form of organization at the Fuel Mines the mechanical loader operator has charge of every man employed in connection with the operation of his machine, including the cutters, shot firers, and motor crew. He is held responsible for the performance of the entire crew assigned to his machine. The mechanical loader operator, his helper, and a mucker do the loading. The mucker is necessary because the seam contains 6 to 14 in. of impurities. The motorman and brakeman constitute the transportation crew; the machineman and helper the cutting crew, and a shot firer and two helpers the shooting crew. The shooting crew also lays all track except switches. Switches are laid by the regular sectional track crew.

Natural conditions in Sarita No. 2 are average. The seam is known locally as the Dorothy and runs from 12 to 14 ft. in height. There are two separate bands of slate 6 to 7 in. thick located 2 and 6 ft. from the bottom, respectively. The roof is slate and it is necessary to leave 12 to 14 in. of top coal up in order to hold it. Where the coal can be left up no trouble from the roof is experienced, but where the top coal comes down it is necessary to timber very closely. Grades average 2 percent away from the face. Drainage is good, although water is very often encountered in local swags, but the loader can operate in 6 in. of water without difficulty.

Transportation has proved exceedingly simple, much more so than was anticipated. All the breakthroughs are turned on an angle of 60 degrees and track laid through each one. By always having track in the three nearest breakthroughs to the face no parting was necessary, as one breakthrough is always open and serves as a run-around. Track is laid on a definite plan (shown in figure "A"), which is rigidly adhered to. Several varieties of patent track extensions were tried but all proved failures, and we now

*General Manager, Fuel Mine Operations, Chesapeake & Ohio Railroad, Dorothy, W. Va.



Instructions—All turn-outs to be standard No. 2 frogs with 12' lead and 21' radius. Original lay-out will be made under direction of engineer after which break-throughs will be turned and frogs heeled in at every third joint. Full length, 30-lb. rail to be used exclusively on frog rail in each entry. Shorter lengths, not less than 10', may be used on opposite rail. All joints to be fully bolted and bonded for return.

CHESAPEAKE-OHIO RY. CO. FUEL MINE OPERATIONS DOROTHY, W. VA.

Track lay-out for operation of mechanical loader at Sarita

use 7-ft. jumpers on steel ties. When four of these jumpers have been laid, a 30-ft. rail is inserted and the track extended, the jumpers being used over and over again.

A time study soon showed that a cut could be cleaned up in an hour. Transportation was so arranged that empties were supplied and loads pulled on the hour, and this schedule was strictly maintained. The gathering locomotive that served the loader was furnished the number of empties necessary to clean up a cut and was due to have these cars back, loaded, where the haulage locomotive could pick them up on the hour. Leaving the track in the last three breakthroughs served to keep a parting close to the face at all times, and aside from a few wrecks practically no lost time can be charged to transportation.

Cutting and shooting gives the most trouble, and it is to this section of the organization that practically all delays occur, for with maximum efficiency the cutting and shooting crew can hardly keep ahead of the loader. The coal is under-cut by a shortwall machine with 7½-ft. cutter bar. The bottom bench of the coal is shot first with three holes, using six sticks of Duobel 2 or equivalent to each. The top is shot with two holes, one on each rib, using six sticks of explosive in each hole. Permissible powder is used to eliminate smoke. Considerable experimenting was done with different speeds of powder and it was found that Duobel 2 or its equivalent is the best. For successful loading it is necessary to shoot the bottom bench hard enough to heave it out so that the top bench, when it is shot, will drop and break. This makes a great quantity of fines, mostly slack, nut, and egg, suitable for our purposes, but hardly suitable for a commercial operation. Considerable difficulty is encountered with hung shots and very often it is necessary to "pop" the corners. Three picks are carried on the loader and very often the loading crew has to "bull" down the coal.

Practically no trouble has been experienced with the loaders, and in the first 16 months only two hours were lost on account of mechanical trouble. In the first year of operation the machine in Sarita No. 2 drove 3,411 yards of entry at a labor cost of $19,565.30 and a repair cost of $137.96.

At the end of 16 months service the first loader was taken out of service solely for the purpose of making a complete examination to find what parts had worn. Everyone was very much surprised to find that practically no part of the machine showed wear, and judging from the service this machine has been subjected to during its 16 months of service, it can readily be expected that, barring accidents, repairs will not be over $.002 a ton for the next two years.

The Dorothy No. 2 mine was opened quite some time later in what is known as the No. 5 Block seam. On the experience gained at Sarita No. 2 the same type loader was purchased. The same type organization, with the exception of the mucker, is used. Natural conditions are average. The seam is 8 ft. thick, has no partings and carries 6 in. of draw slate with a sand rock roof. The same track arrangements are used, but the coal is cut with arc-wall and straight-face machines. No delays have been experienced with the cutting and the shooting. In this mine the machines have averaged as high as 72 ft. of entry a day. It is our experience that for entry driving under our conditions arc-wall type cutting machines should be used in connection with the loaders. Although shooting behind an arc-wall has not been any more successful than shooting behind a short-wall, time is saved in cutting the places and in track work.

Two simple reports are used for each machine — one from the mechanical loader operator and one from the shot firer. From these reports the daily cost of operation of each loader is figured. Each week the foreman in charge of the section is required to make up a weekly report summing up the activities of the loaders in the section for the week. This report shows the number of yards of entry driven, number of tons loaded, number of cars of coal, number of cars of slate, number of feet of track and switches laid and the total number of detonators and sticks of explosives used.

Benefits derived from the use of mechanical loaders have been so far reaching in their affect on the operation of the mines as a whole that it is almost impossible to estimate, with accuracy, just how much in dollars the use of the machines is reflected in the total cost of production. At Sarita No. 2, after a year of careful analysis, there was found to exist a differential of a little over 9 cents a ton in favor of the mechanical loaders as against hand loading methods. This figure was arrived at by assuming that it would have been possible to produce a like tonnage by hand loading methods, which, of course, is impossible. No value was assigned for the increased development which permitted the tonnage from Sarita No. 2 to balance the decreasing tonnage at Sarita No. 1. This figure will represent at least 5 cents a ton in that the balanced production prevented an increased cost of a like amount at Sarita No. 1 over whose tipple the coal from Sarita No. 2 is dumped. It is interesting to note that in less than a year the tonnage from Sarita No. 2 was raised from 200 tons to 900 tons a day.

Since July 1, Dorothy No. 2 has been made a mechanical mine using shovel type loaders and the results so far are most gratifying, but it is yet too early to form any definite conclusions on just what is being accomplished.

METAL MINE TAX LAWS

(*Continued from page* 654)

ployes, other than corporate officers, within the state. The surface ground is valued by county assessors; all other mining property by the state board of equalization.

Washington

Mining property is assessed by county assessors, in accordance with their judgment as to its value, on the same basis as other properties.

A trial plant for the production of gasoline from lignite is being installed at Saint-Julien de Peyrolas, France, the lignite to be obtained from a mine belonging to the operating company. The furnace has a daily capacity of 60 tons and is expected to produce from 80 to 100 liters of high grade gasoline per ton of lignite in addition to numerous by-products, the chief of which is sulphur.

THE NECESSITY FOR SHORT FLAME EXPLOSIVES IN COAL MINES*

Accidents From Blasting—Tests For Permissible Explosives—Safe And Unsafe Drilling And Shooting Practice—Lump Coal Possible With Proper Use Of Permissible Explosives

By D. HARRINGTON† AND G. ST. J. PERROTT‡

IT is probable that over 95 percent of the coal production of the United States is dependent upon the use of explosives before it can be placed in the railroad car at the mine, and up to the present time it has been impossible to secure any kind of practicable explosive which isn't dangerous unless handled carefully. In other words, there have been found up to this date no "fool-proof" explosives, and an inspection of the accident records of our coal mines indicates that the use of explosives in coal mines has taken a sad toll of lives.

ACCIDENTS FROM EXPLOSIVES IN COAL MINES

Out of about 2,000 to 2,500 persons killed annually in our coal mines, there are about 100 to 125 killed from explosives without there having been an explosion of gas or dust, these accidents being due to misfires or hangfires or premature blasts or accidental setting off of explosives due to carelessness or otherwise (but chiefly to carelessness in some form). In this type of accident the flame character of the explosive is not necessarily involved, though it is far easier to cause an unexpected or premature blast with black blasting powder, which has a long flame, than with a permissible explosive, which has a flame much shorter and of briefer duration. By far the greater number of the above mentioned accidents are encountered in the use of black blasting powder or dynamite rather than with permissible explosive.

While the hazard due to premature blasts above discussed is much greater with the long flame black blasting powder than with the much shorter flame permissible explosives (and this alone should outlaw black blasting powder from coal mines), by far the greater hazard from long flame explosives (black blasting powder) is found in the fact that about one-third of our coal mine explosions have been initiated by blown-out shots or other effect of misuse of explosives, and at least 90 percent of these explosions have been due to black blasting powder. In some regions with a record of numerous explosions, blown-out shots (chiefly of black powder but occasionally of dynamite) have caused two-thirds of the disasters. In addition practically innumerable fires have been caused by black powder or dynamite shots in coal mines and one mining company having fewer than 10 mines had a record (covering a period of several years) of more than one fire per week from blasting with black powder or dynamite or a mixture of the two.

In a partial list of coal-mine explosions investigated by the United States Bureau of Mines, 1910 to November, 1926, involving 144 disasters with 3,756 fatalities, 80, or 30 percent, were from blown-out shots and it is thought that black blasting powder was responsible for at least 70 of the 80. In this list of 80 disasters from blown-out shots, 12 were from Kansas, 13 from Oklahoma, 14 from Indiana, with the remainder scattered through 14 other coal-mining states. In a list of coal-mine explosions which occurred from 1908 to 1923 (U. S. Bureau of Mines Serial 2583) 71 were charged against black powder and dynamite, the resultant deaths being 857. In another list of 187 coal-mine disasters in the United States with 3,843 fatalities covering a different 17-year period, 75 or 40 percent were charged against explosives, deaths being 832, and it was estimated that at least 90 percent of the explosions due to explosives were from black blasting powder and dynamite. In a more recent list of coal-mine disasters in the United States (from January 1, 1919, to April 1, 1924) out of 61 ex-

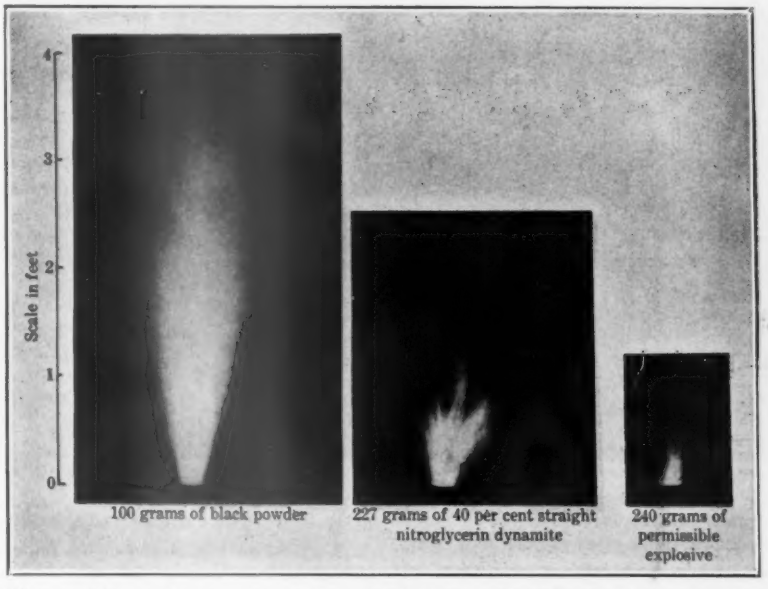


Fig. 1. Flame photographs of stemmed shots of explosives fired from a cannon

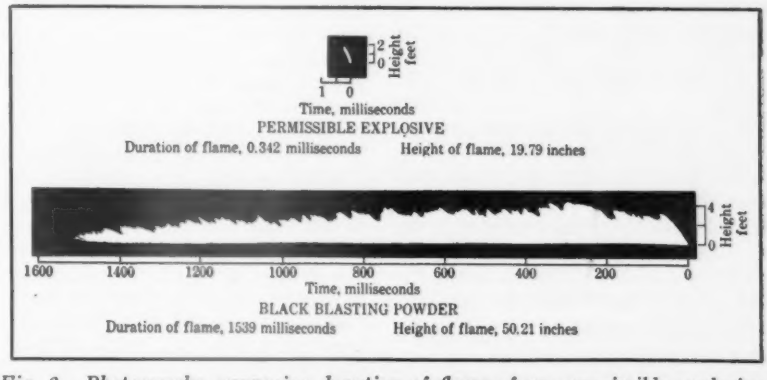


Fig. 2. Photographs comparing duration of flames from permissible explosive and from black blasting powder

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† Chief Engineer, Safety Division, U. S. Bureau of Mines, Washington, D. C.
‡ Supervising Chemist, Explosives Section, U. S. Bureau of Mines, Pittsburgh, Pa.

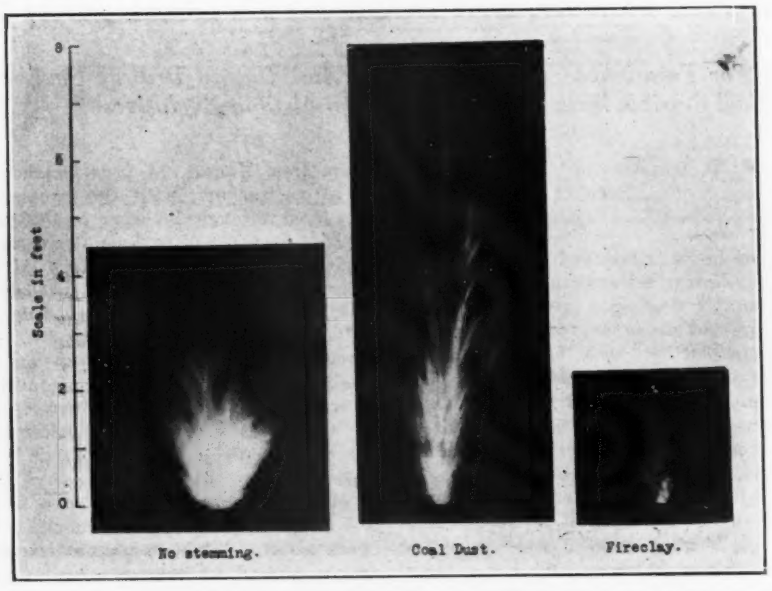


Fig. 3
Flame photographs showing effect of charge of stemming

Fig. 4
Miner snubbing undercut coal preparatory to drilling shot holes and shooting down coal

plosions with 1,087 fatalities 17 or 28 percent were charged against explosives, there being 187 deaths; and black blasting powder or dynamite were involved in at least 14 of the 17.

The record as to responsibility for coal-mine explosions is by no means favorable to explosives and this fact was recognized more than 20 years ago. This was one of the most pressing problems which confronted the Bureau of Mines upon its creation in 1910; as a result, the bureau entered upon a vigorous study of the nature of explosives and of testing of explosives as to their suitability for use in coal mines, developing what is known as its permissible explosives list, though "short flame" explosives were being used to a limited extent at least as early as 1902.

* This is called a test of safety because insensitive explosives may burn in the hole and so cause ignitions of gas or dust in the mine.

The Testing of Permissible Explosives

A permissible explosive is an explosive which has passed certain tests made by the United States Bureau of Mines at the Explosives Experiment Station, Bruceton, Pa. After the explosive has passed these tests, it is placed on the official list of explosives permissible for use in coal mines and may be sold as a permissible explosive. To protect the user, the bureau also sees to it that the explosive actually marketed is identical in properties with the sample originally submitted for test. This is accomplished by securing field samples which may be bought on the open market or secured from magazines at coal mines where the explosive is being used. These field samples are brought to the Explosive Experiment Station and again subjected to the tests which the basic sample originally passed.

The tests to which coal mine explosives are submitted may be divided roughly into two classes: (1) tests of efficiency and (2) tests of safety.

Tests of Efficiency

An explosive owes its action in breaking rock or coal to the development in a small time interval and within a relatively small volume of a large mass of hot gases. We distinguish two factors as determining the effect produced by an explosive: (1) Propulsive or heaving effect per unit volume; (2) rate of detonation. The propulsive or heaving effect is determined by means of the ballistic pendulum and the results are expressed as the number of grams of the explosive which will give the same swing as 227 grams, one-half pound of 40 percent straight nitroglycerine dynamite. The unit deflective charge of the various permissible explosives ranges from 205 to 350 grams. The rate of detonation and speed of the explosive is measured by means of an instrument called the Mettegang recorder, and for permissible explosives this speed varies from about 6,000 to 15,000 feet per second.

Tests of Safety

Under tests for safety we have (1) the gallery tests, (2) determination of noxious gases produced by detonation of the explosive, (3) test to determine the sensitivity to detonation by influence, i. e., the length of air gap across which detonation will be transferred from one cartridge to another,* and (4) resistance to detonation by frictional impact.

The Gallery Test

In the gallery test which is designed to simulate conditions in a coal mine, a charge of explosive is fired from a steel cannon into a large steel tube or gallery (six feet in diameter) containing a combustible mixture of air with gas or coal dust, or both. It is this gallery test which tells us whether or not an explosive is liable to cause ignitions of gas or coal dust in actual mining operations. Two gallery tests must be passed—Test 1 and Test 4. In Test 1 a unit deflective charge of explosive tamped with 1 pound of dry fireclay stemming is fired into a mixture containing 8 percent natural gas. If no ignitions occur in 10 shots the test requirements are satisfied. In Test 4, 1½ pound of explosive is fired into the gallery which now contains 4 percent gas and 20 pounds of pulverized Pittsburgh coal on the shelves. No ignitions must occur in five shots.

Reasons for Greater Safety of Permissible Explosives

Permissible explosives differ from black powder and from the metal mining explosives in that they produce a smaller flame of lower temperature and shorter duration. Figure 1 shows the difference between the flames produced by permissible explosives and other explosives.

Fig. 5. Miner drilling six-foot hole in working face

Fig. 6. Shotfirer tamping hole in face of room

These are photographs of flames produced by charges of explosives fired from a steel cannon into the air or essentially what is known as a blown-out shot in a coal mine. The weights of permissible explosives and 40 percent nitroglycerin dynamite used were equal in strength as determined by the ballistic pendulum, whereas the quantity of black powder used was about one-fourth the strength of the charge of the other two explosives. A larger quantity of black powder gave a flame too voluminous for the scale of the photograph, but even from this amount of black powder it will be seen that the flame is considerably larger than for the other two explosives and evidently extremely likely to ignite explosive mixtures of air with gas or coal dust. The flame from permissible explosives is considerably smaller than that with 40 percent dynamites. Photographs taken on a moving film show further that the flame of the shot of black powder is of considerably longer duration than that of the permissible explosive. In Figure 2, in which the photographs were taken on a moving film, this effect is shown graphically.

Permissible Method of Using Explosives

The word "permissible" refers not only to the explosive itself but also to the method of using the explosive underground. Thus, in addition to specifying that the explosive actually used should be similar in all respects to the sample submitted by the manufacturer for test, the bureau specifies the use of electric detonators, states that the explosive must not be used in a frozen condition, and that the quantity used for a shot must not exceed 1½ pound and that it must be properly confined with clay or other non-combustible stemming. The bureau also advocates that all coal which it is feasible to cut should be cut or sheared.

Danger of Blown-Out Shots or Use of Coal-Dust Stemming

The effect of the conditions of use on relative safety is graphically shown by the photographs in Figure 3, which are all pictures of shots of the same permissible explosive but fired with different types of stemming. These photographs illustrate the reason for the bureau's recommendation that permissible explosives be used only in a certain approved manner. Comparison of the photographs of a shot fired without any stemming with that in which fireclay stemming was used shows the great danger of an unstemmed shot; it is almost a certainty that if *any* explosions have been caused by permissible explosives, they have been initiated because the permissible explosives were either unstemmed, insufficiently stemmed or too much explosive used. The shot in which coal dust was employed as stemming illustrates the danger of using combustible stemming.

This danger has been well demonstrated in a recent series of tests in which 1½ pounds of permissible explosive was fired into the gallery which contained 4 percent of gas and 20 pounds of coal dust on the shelves. When no stemming at all was employed this explosive caused no ignitions in 10 shots. When one-quarter pound of coal dust stemming was placed in the borehole five shots out of six caused ignitions. The first condition with no stemming is identical with the conditions of Test 4, which is one of the tests all explosives on the permissible list must pass. It is evident from the above results that coal dust stemming increases the danger greatly over that existing when no stemming is used.

Why Permissible Explosives are Safer Than Black Blasting Powder

An inspection of Figure 1 shows the enormously greater volume of flame found when about one-fifth of a pound of black blasting powder is used as against the much smaller flame from one-half pound of 40 percent dynamite, and the vastly diminished volume of flame from about one-half pound of permissible explosive. If the flame from one-fifth of a pound of black powder *stemmed* and fired from a cannon is 4 feet in length as shown in Figure 1, what would be the length of flame when 4, 5, 6 or more pounds are used in one shot, as is so frequently done in black powder blasting, especially in solid shooting? Moreover Figure 2 shows that the black powder flame lasts 1,539 milleseconds or 1.54 seconds against but 0.342 milleseconds or 0.000342 of a second with the permissible; hence the flame from black blasting powder in addition to being enormously greater in volume than that from permissible, also lasts or has a duration of 4,500 times as long as the permissible explosive flame. Hence black powder flame not only extends to a great length and has definite dimensions as to breadth and thickness and it lasts more than 1½ seconds, hence is in existence a material length of time while the flame from permissible explosive does not extend anything like as far in length, breadth or thickness and it exists for but three ten-thousandths of a second, hence does not have a sufficient time interval to cause an ignition of gas or dust or of a mixture of both.

However, Figure 3 shows that even the permissible explosive can have a dangerous amount of flame if fired without stemming and is even more dangerous when stemmed with coal dust, and, on the other hand, the flame produced when the permissible explosive is stemmed with fire clay is negligible.

Permissible Explosives Safe When Used Sanely

Bureau of Mines early took a decided stand against the use of black blasting

Fig. 7. Shotfirer attaching wires to charge at working face preparatory to shooting down coal, after undercutting. The shooting is done electrically and but one shot is fired at a time. The shotfirer has apparently tested the surroundings as to methane

Fig. 8. Shotfirer setting off charge. When shooting is done when the shotfirer or other men are in the mine, the only reasonably safe method known is the firing of one shot of permissible explosive at a time, using a one-shot firing device as shown here.

powder or dynamite in coal mines, because it was absolutely demonstrated that either black blasting powder or dynamite would ignite either explosive gas or bituminous or lignitic coal dust, and this was proven both in the laboratory and in the investigations in coal mines after disasters. On the other hand, it has been amply proven, both in the laboratory and in mine use, that the explosives on the Bureau of Mines permissible lists do not ignite either gas or dust if used in a permissible or sane way as stipulated by the bureau and as heretofore indicated in this paper. It is true that a few explosions or fires in coal mines in the United States have been assessed against permissible explosives (not to exceed 1 percent of those charged against explosives in general), but when the evidence is *"sifted down"* it almost invariably is found that the explosive was *misused;* in at least one instance a quantity of permissible explosives was detonated prematurely while on the floor of a coal mine working place; in another instance an explosion was blamed against permissible explosives in a mine where overcharging of holes (using much more than the allowable 1½ pounds per hole) was the rule; moreover, in this instance, matches and smoking materials were found on several of the bodies taken out of this *closed* lamp, gassy mine, and it is very probable that a smoker ignited methane to start the explosion; in another instance numerous fires were charged against permissible explosives until it was found that the miners were accustomed to smuggle dynamite into the holes before the shotfirer loaded these holes with permissible; in other cases permissible explosives were blamed for fires and explosions when, as a matter of fact, the ignition was undoubtedly due to using an open light and fuse to detonate the explosive instead of the much safer electric detonators; in one mine numerous fires and some explosions occurred at blasting time when the main 500-volt current was used to detonate the explosive, the permissible explosive being blamed, and it was found after an exhaustive investigation that the fault lay with electrical ignitions of gas and dust *after* the shots were fired, the arcs coming from the high voltage current in the tangled shot wires, the situation being wholly remedied when voltage was reduced to less than 100 and current held in the shooting lines but a fraction of a second.

Progress Toward Adoption of Permissible Explosives

When the dangers encountered in using either black powder or dynamite in coal mines are given serious consideration, it is difficult to realize why but about one-third of our coal comes from mines using permissible explosive. However, the mines using black blasting powder and dynamite are now generally taking many precautions against disaster, such as rock-dusting fairly close to the face, or using shotfirers to do the blasting after the shift, etc. While progress has been slow toward the universal elimination of black blasting powder and dynamite from our coal mines, a tabulation on page 10 of the U. S. Bureau of Mines, Serial No. 2816, indicates that real, if slow, progress is being made toward adoption of permissible explosives in both bituminous and anthracite mines, elimination of black blasting powder is proceeding rapidly in anthracite mines and much more slowly in bituminous mines, and it appears that the anthracite people are increasing the use of high explosives (dynamite) and bituminous mines were using essentially the same quantities of dynamite per 1,000 tons of coal produced in 1926 as in 1912. There is no good reason why dynamite should be used in any coal mine, as it is dangerous as to ignition of either gas or dust and there are permissible explosives which can do the work required

of dynamite. An explosives expert recently wrote as follows:

"We have a permissible called ....., which is somewhat denser and more water resistant, of course, than 40 percent dynamite and has the same strength, or greater strength, than 40 percent dynamite on a bulk basis. We have had this explosive on the market for three years, and it is being used in quite a number of mines not only for coal but also for rock. I venture to say that it will shoot any rock to be found in coal mines, certainly as effectively as any 40 percent dynamite and possibly as effectively as 60 percent dynamite."

From the above it will be seen that, notwithstanding the very extended use of dynamite in both anthracite and bituminous mines, there are much safer permissibles, which can effectively shoot either rock or coal in any coal mine, and the permissibles are by far safer than the dynamite.

Why Permissible Explosives Are Not More Widely Used in Coal Mines

Probably the main reason why permissible explosives have not been adopted more extensively is that mining men believe that the permissible explosive unduly breaks the coal or, even if lumps are secured, they are so shaken or shattered that they readily break upon being handled. There is some foundation for this belief, but where the blasting is done under careful supervision (as all blasting should be) the amount of additional small sizes or shattering of coal, when using permissibles, is negligible, if at all existent. Probably the greatest bar to successful efficient use of permissible explosives is the disinclination of the miner to drill a sufficient number of holes to allow of bringing down the coal with a reasonable quantity of explosive per hole; the miner drills as few holes as he "*can get away with*" and then places an excessive amount of explosive in each hole (frequently 2, 3 or more pounds instead of the 1½ pounds permissible limit), and the result is almost certain to be shattered coal and probably shattered roof as well.

Mining people, and especially the miner himself, also believe that shooting with permissible explosive is more expensive than with black blasting powder. Where slip-shod mining or shooting practices are in use, and the miner handles the blasting as he sees fit, the cost is very likely to be excessive, especially if the miner is required to use the permissible explosive against his will; however, where the mining methods are reasonably efficient with coal cut, cuttings removed from the kerf, a sufficient number of holes drilled and placed with judgment and the blasting done by carefully chosen shotfirers, cost need not be greater with permissible than with black blasting powder, and in some instances the balance is in favor of the permissible. While permissible explosives are not efficiently applicable to solid shooting, they are far safer in this work than either black blasting powder or dynamite. Solid shooting, however, is dangerous with any kind of explosive and should be prohibited by state law.

Fig. 9. This photo shows the flame at the face of an entry in a bituminous coal mine where detonator wires carrying 500 volts D. C. were short circuited at or immediately after blasting. This caused several fires and some explosions and was remedied by reducing voltage to less than 100 and by limiting the duration of electrical current in the blasting lines to about ½ second.

In a formal declaration of policy announced in 1926 the U. S. Bureau of Mines takes an unequivocal stand as follows:

"In the interest of safety the Bureau of Mines recommends that for blasting in coal mines permissible explosives fired electrically be exclusively used, and that as an aid to blasting all coal which is feasible to cut should be cut or sheared."

Utah is the only state in the Union which prohibits the use of black blasting powder and dynamite in its coal mines, and it is difficult to understand why similar action is not taken by every state which produces coal.

Necessity for Further Development Work

While the past record of permissible explosives has been most gratifying, it is very desirable that we pave the way for further improvement in explosives and blasting methods by learning more about the mechanism of ignition of gas and coal dust by explosives. To this end a considerable amount of investigative work has already been carried out at the Explosives Experiment Station and a large amount yet remains to be done. An attempt is being made to unravel the mystery which still surrounds the ignition of gas and coal dust mixtures by explosives. The factors that affect the liability of an explosive to ignite gas or dust are already known in a qualitative way, but quantitative data are for the most part lacking. It is generally conceded that the relative safety of an explosive as regards igniting combustible mixtures depends upon (1) temperature, size and duration of flame, and (2) heating of the combustible mixture produced by adiabatic compression as the hot gases are rapidly discharged from the borehole. These factors not only depend upon the character of the explosive but also upon the position of the borehole with regard to the entry, the size and form of entry or room in the mine, the method of loading in the borehole, its diameter and length, size of cartridge, and type of stemming employed. The effect of these various factors on safety is being investigated at the Explosives Experiment Station in the testing galleries, and various properties of the explosives themselves, such as temperature and pressure produced upon detonation, are being measured. An interesting feature of the work is the application of high-speed photography to determine the exact mechanism of the ignition of gas and dust mixtures by explosives. A special gallery and camera have been constructed by means of which the ignition process can be followed from the moment the flame of the explosive issues from the borehole.

In conclusion, it should be emphasized that the terms "explosive" and "safe" are essentially contradictory, and it is doubtful if we shall ever develop a "fool-proof" explosive or an efficient explosive which is flameless. This makes even more essential the use of permissible explosives in a permissible manner, which represents the best combination of safety and efficiency in blasting that the combined efforts of investigators in Government and commercial laboratories have been able to develop up to the present time.

METALS

PRACTICAL OPERATING MEN'S DEPARTMENT

GUY N. BJORGE, Editor

Practical Operating Problems of the Metal Mining Industry

HOISTING OPERATIONS AND EQUIPMENT AT NO. 7 SHAFT, DESLOGE CONSOLIDATED LEAD COMPANY

Skip Hoisting And Cage Hoisting Discussed—Cycle Of Haulage Operations Determined—Automatic Locking Mechanism And Cagers Installed—Efficiency Demonstrated

By H. A. NEUSTAEDTER *

AFTER examining several plants and watching their hoisting operations with skips, we visited the Thermal Mine of Donk Bros. Coal Co., Thermal, Ill., where skip hoisting is used in the main shaft, and Allen & Garcia overturning type cages used in the auxiliary shaft.

Considerable discussion was entered into before we finally decided to adopt Allen & Garcia overturning cages and their uniquely designed headframe.

In these discussions the advantages of skip hoisting over cage hoisting were taken up and a general outline of these advantages taken from different articles in technical publications.

Following are the advantages of skip hoisting over cage hoisting, with notes to show where they were not of great importance when our particular conditions were considered. To further offset these advantages for skips we saw some advantages for cages that were due to our local conditions, and were the deciding factors in making final decision:

SKIP HOISTING

(1) Smaller shaft as first cost factor. (We figured that with our method of shaft sinking we could sink a larger shaft to the bottom level, cheaper than we could sink a smaller shaft deeper in a wet porous sand rock for a skip pocket.)

(2) Greater hoisting capacity. (We could easily get the capacity we wanted with cages hoisting 2-ton capacity cars.)

(3) Lower rope speed resulting in less power used per ton rock hoisted. (Rope speed not excessive and power used was about a stand-off because we would have to hoist from a 20 percent greater depth with skips than with cages.)

(4) Heavier loads of ore per trip with same gross load on rope. (A true advantage. Cages had no offset for this.)

(5) No trouble from cars missing hook and not dumping which might cause delays. (No trouble because we would use overturning cage that dumps same as skips.)

(6) Use of solid end cars instead of cars with open end and gate for dumping. (We would use solid end cars with the overturning cages.)

(7) Require less men for operation. (By using automatic cagers number of men required appeared to be the same.)

(8) Rest period shorter. (This might apply to hand caging but with automatic caging rest periods are 3 to 4 seconds shorter, and in favor of cages, due to rapidity of caging cars.)

(9) Storage capacity underground

Fig. 2—View of head frame, Desloge Consolidated Lead Co. Roof of hoist house barely visible at left above retaining wall

* Engineer, Desloge Consolidated Lead Company, Desloge, St. Francois County, Mo.

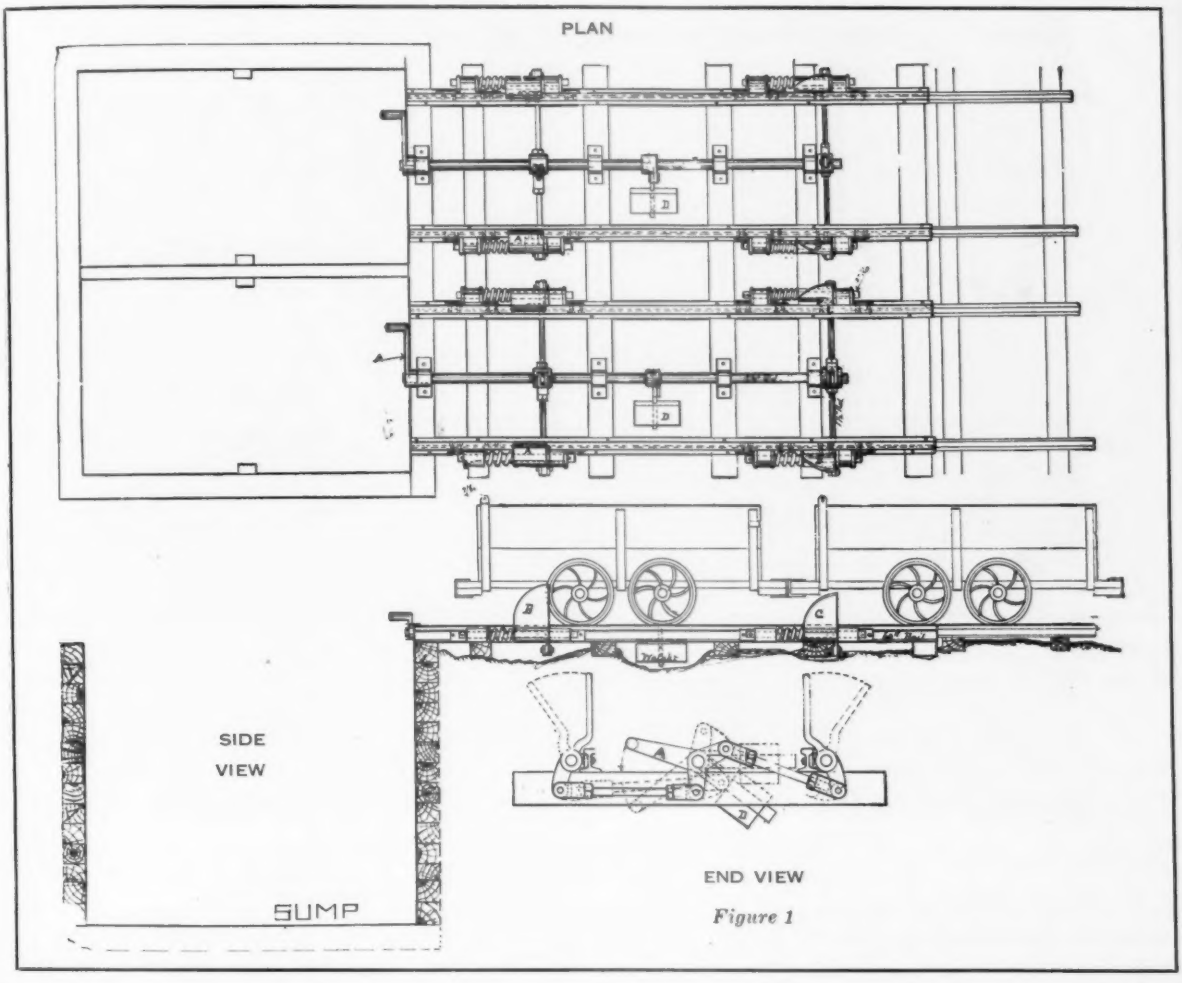


Figure 1

to act as fly wheel in operations. (We have several chutes for ore from upper levels with more storage capacity than we could have in skip pocket. For the cost of the skip pocket we could build enough cars to give us the same storage. Our operating men were unanimously in favor of the extra cars.)

The following are the advantages of cage hoisting:

Cage Hoisting

(1) No hoisting delays because of rock wedging in main skip pocket, or measuring pocket.

(2) No delays on locomotive when emptying cars in rotary dump.

(3) No large investment in skip pocket. Pocket would have to be cut in a very porous and wet sandstone, necessitating concreting. Keeping seepage out of the skip pocket would probably be very difficult if not impossible at the cost allowed for the pocket.

(4) Ore in the pocket would absorb considerable moisture, which in turn would cause considerable trouble in our fine crushing plant centralized at this shaft.

This last point was probably the determining factor of the whole discussion.

Haulage System at Shaft

The drawing shown in figure 3 shows the plan of the haulage system at the shaft. Loads are brought in from "N" or "S" main haulage line and set in on load track "A" or "B," which have a total storage capacity of 80 cars. These cars are fed to Allen & Garcia overturning cages by Nolan Automatic Cagers described elsewhere in this article. The tracks on the lower side of the cage have a crossover so that empties can be shunted to either track "C" or "D" for cleaning, and for making up trips on track "E." On track "E" is always a trip of the correct number of cars made up for the locomotive. Track "E" has a capacity of 40 cars which is the maximum size trip. The combined capacity of "C" and "D" is also 40 cars.

As soon as the trip is taken from track "E" cars from "C" and "D" are dropped down for the next trip. The men knowing the cycle of haulage operations and number of cars required for various headings always have the correct number of cars ready for the locomotive. By this arrangement we have reduced locomotive delays at the shaft. The men required at the shaft to carry on this work are one cager, one

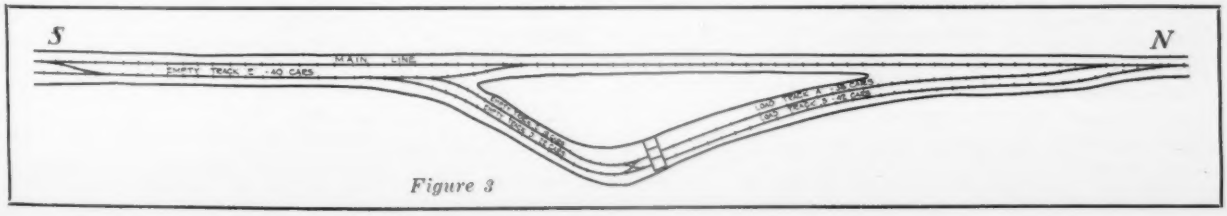


Figure 3

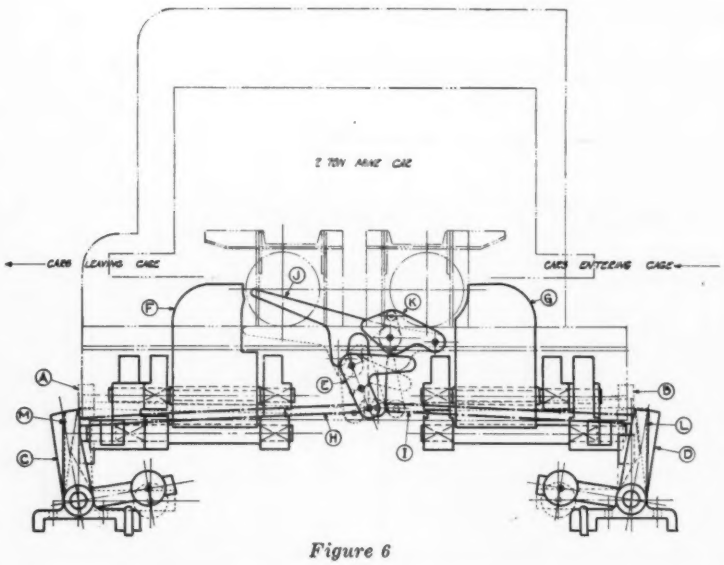


Figure 6

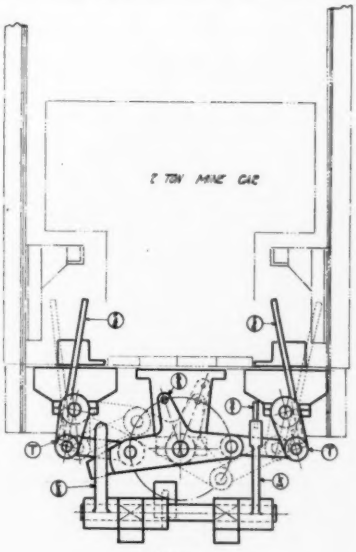


Figure 5

man to switch cars and a coupler who also does some car cleaning.

Equipment

Hoist

The hoist is a single cylindro-conical drum type made by the Ottumwa Iron Works. This hoist has single reduction gears with pinion running between two bearings and connected to a 150 h.p., 435-r. p. m., 2200-volt, 3-phase, 60-cycle, 40-degree, continuous-rated, variable-speed, slip-ring General Electric Co., form M motor, by a flexible coupling. The control for this motor, both primary and secondary, are of the automatic contactor type, operated through a General Electric master switch, which is manually operated. The control current is 440 volt, supplied through single phase transformers, 2300/440 volt.

The hoisting conditions are:

Weight of cage, 10,000 lbs.; weight of cars, 2,000 lbs.; weight of ore, 5,000 lbs.; cage travel, 326 ft.; size of rope, 1¼-in.; trips per hour, 95; rest period, 6 seconds; balanced hoisting and end lift.

The most important points of present day installations are their safety features. This hoist is equipped with a Lilly Governor driven from the main shaft by gears and so designed as to break an electric circuit upon overspeeding, approaching the dump too rapidly, overwinding or starting the hoist in the wrong direction. The breaking of this circuit is arranged to shut off the power and apply the brakes, regardless of the position of the operating levers.

In addition to the Lilly Governor we also have track limit switches as additional protection from overwinding. Another patented safety feature of this hoist is that, if the operator fails to keep the power brake in proper adjustment, an alarm will be sounded, and if unheeded the brake will set and power will be interrupted and remain so until the operator has readjusted the brake.

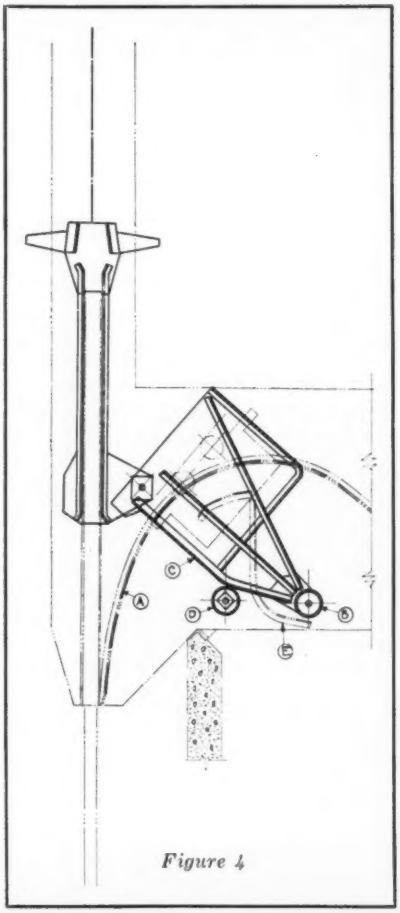


Figure 4

The braking system is of the oil type, consisting of an accumulator automatically controlling a continuous supply of oil under constant pressure, which through a patented proportional pressure control operates the brake.

The brake is operated by a weight acting on the plunger of the thrust cylinder so that the brake is applied by gravity and released or controlled by oil in the thrust cylinder.

Head Frame and Cages

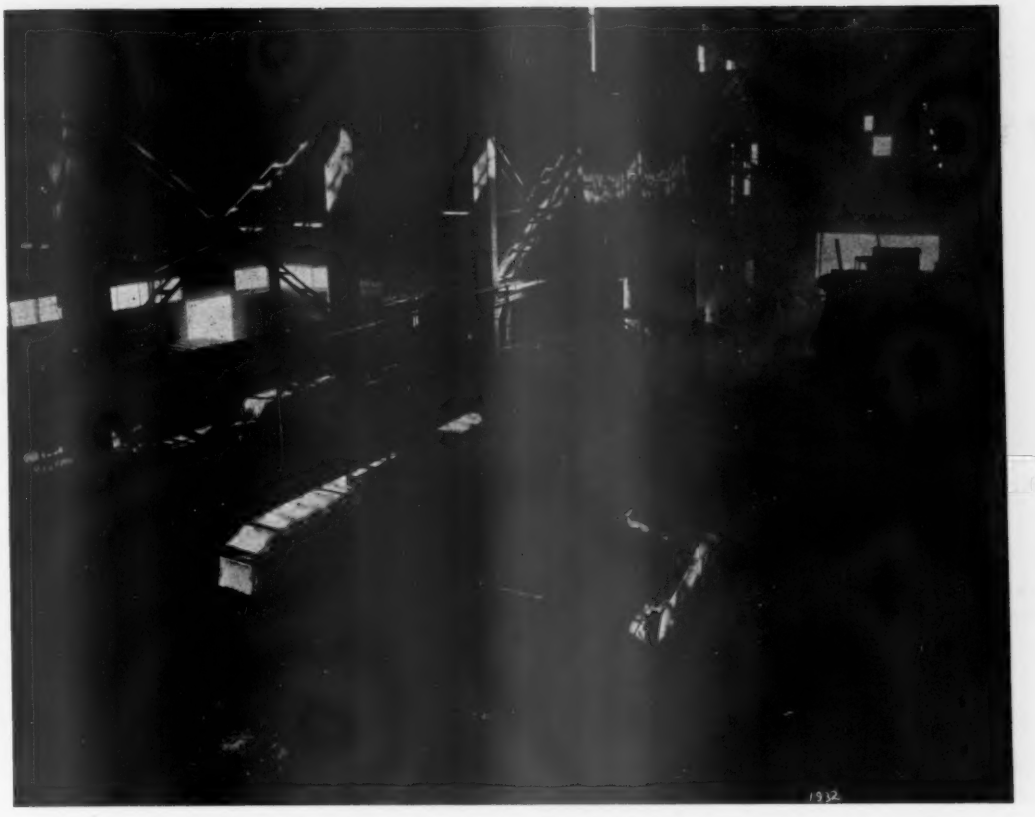
Head frame and cages were designed and installed by Allen & Garcia Co., the cages being manufactured by The Connellsville Mfg. & Mine Supply Co.

The head frame is for end pull and designed so that there is a very narrow, rigid front leg, with all lateral bracing taken care of in designing of shed over ore bin, as shown in figure 2.

The cages are of the overturning type for use of solid end cars, and are equipped for caging automatically.

Figure 4 shows the cage in dumping position. When the cage goes into dump, wheels "B" follow track "A" until load is overbalanced, and bail "C" of dumping section rests on wheel "D" and dumping cycle is completed as curve of bail "C" passes over wheel "D." Track "E" is only for taking care of overwind.

The description of operation of mechanism for automatic locking cars on cages, with reference to figures 5 and 6 is as follows: When cage approaches bottom, seat on levers "A," "B," "H" and "I" rests on chairs "C," "D," "L" and "M," and as cage continues to its resting place, levers "A" and "B" actuate horns "F" and "G," allowing car to pass from cage. The car leaving the cage allows levers (*Continued on page* 728)



Casting Blister Copper, Nevada Consolidated Copper Company, McGill, Nevada

GENERAL IMPROVEMENT IN CONVERTER PRACTICE

Peirce-Smith Type Of Converter—Enlargement Of Vessels, Together With Improved Tilting Arrangement, Has Been Productive Of Greater Efficiencies—Life Of Lining Increased By Proper Manipulation

By LEONARD LARSON *

THE use of a basic (magnesite) lining in copper converters, which was first definitely proven as practicable by W. H. Peirce and E. A. C. Smith at the works of the Baltimore Copper Smelting Co., marked the beginning of the greatest single improvement in copper converting practice. During the year 1910 at Garfield and other plants the successful, practical application of the basic lining in copper converting was further definitely established. The superiority of the basic lining over acid lining was soon definitely proven and within a comparatively short time most of the converter plants in the United States were operating with basic linings.

The advantages of the basic converter lining over acid lining are, of course, very well known. However, since the general adoption of the basic lining, a great many improvements in converting practice have been made and it is with some of these that this article will deal.

The original Peirce-Smith basic lined converters were 10 ft. in diameter by 24 ft. long. The throat or gas discharge opening of these converters was on top and near one end. Copper and slag were poured from openings in the side. These converters were tilted by the use of cables attached to the circumference of the shell. The tilting arc was only slightly more than sufficient to put the converter into blowing position as one extreme, and into copper pouring position as the other extreme. The tilting mechanism on most of these 10-ft. by 24-ft. converters has been changed so that they may be turned through an arc sufficient to blow, skim slag and pour copper through the throat or gas outlet. This mechanical improvement speeds up the rate of production considerably by eliminating the delays of opening and closing the slag and copper holes for skimming and pouring copper.

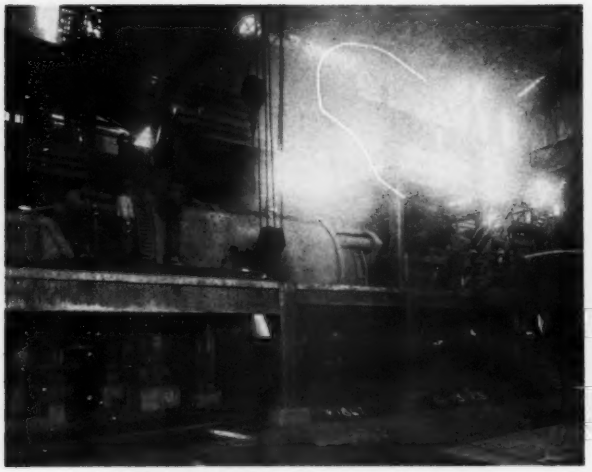
Shortly after the introduction of the 10 by 24-ft. Peirce-Smith converter a program of enlargement was started, until at the present time practically no converters of the Peirce-Smith type are constructed less than 12 ft. in diameter, and probably the majority of the installations in use today are 13 ft. in diameter. The length of these 12 and 13-ft. converters range from 20 to 30 ft.

All of these larger converters are electrically driven and have a tilting arc sufficient to charge, blow, skim and pour copper through the one central gas outlet.

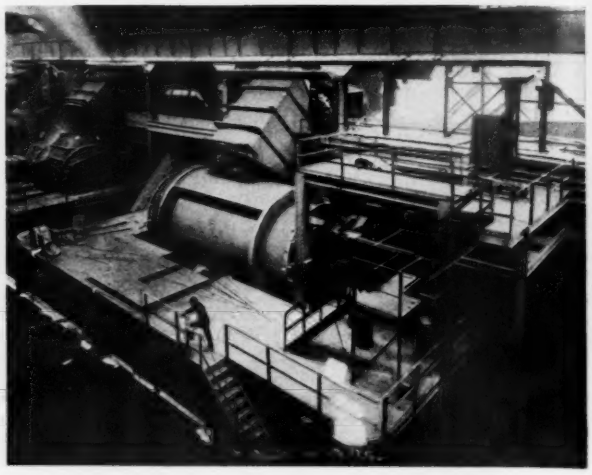
The enlargement of the converter vessel, together with the improved tilting arrangement, was productive of much greater converter capacities and efficiencies. This may be illustrated by the comparative figures on the following page.

The above figures are representative only and are given to show in a general way increased capacities and efficiencies of the larger converters with modern tilting devices.

* Smelter Superintendent, Nevada Cons. Copper Co., McGill, Nev.



Pouring copper from 12'x30' Peirce-Smith convertor, Nevada Consolidated Copper Company



New 12'x30' Peirce-Smith convertor in foreground, old 10'x24' convertor at left

A great deal of work, both practical and experimental, has been done during the last several years in attempts to increase the life of converter linings. These efforts have met with varying success, but it has definitely been proven that by proper converter manipulation the life of the lining may be increased. At some plants the practice of coating the converter lining from time to time with so-called magnetite is employed. This practice has resulted in increasing the life of the lining. At other plants a magnetite slag is made in one converter and poured into another converter where it is allowed to solidify in the tuyere section, thus making the repair without the use of magnesite brick. This practice has also proven very successful.

The problem of increasing the life of the converter lining is a very material one and has been given a great deal of attention at different plants. There has, however, been no universal adoption of any particular means of protecting the lining. At a number of plants no method of protection is employed other than proper manipulation. Referring to the tabulation showing improved converting practice, note that the magnesite consumption per ton of blister produced in the 12 by 30 ft. and 13 by 30 ft. converters has dropped to a point where it is a comparatively small factor in converting costs.

In the original 10 by 24 ft. Peirce-Smith converters flux was added through the gas discharge or some other hole in the top of the converter by means of a boat and crane or bin and chute. This method of adding flux has practically been superseded by the use of a flux gun and air pressure to blow flux into the converter through the ends.

The Great Falls converter has not been mentioned in this article for the reason that the writer is not familiar with this type. However, from what observations I have been able to make, I believe that what has been said above about improved Peirce-Smith practice is in general true also of the Great Falls type converter.

TABULATION SHOWING IMPROVED CONVERTING PRACTICE

Size of Peirce-Smith converter.	Matte grade.	Average copper charge.	Average copper produced per operating day.	Average copper production per campaign.	Average consumption of magnesite per ton blister produced.
		(Tons)	(Tons)	(Tons)	(Pounds)
10' x 24'	40%	20 to 50	50	5,000	8 to 12
11' x 24'	40%	30 to 50	60	8,000	6 to 8
12' x 30'	40%	45 to 65	85	12,000	4 to 6
13' x 30'	40%	50 to 80	105	16,000	2 to 4

HOISTING AT DESLOGE CONSOLIDATED LEAD CO.

(*Continued from page* 726)

"J" and "K" to spring up, due to springs, which in turn pull levers "H" and "I" off of chairs "L" and "M" and in a position to move chairs "C" and "D" away from levers "A" and "B." The loaded cars coming on the cage presses lever "K" which in turn operates lever "H" through bell crank "E" to disengage chair "C" from lever "A" and close engaging horn "F" which stops oncoming loaded car in proper position. The front wheels of loaded car in coming to resting position actuate lever "J," which in turn disengages lever "B" from chair "D" by thrust lever "I" and locks rear wheels on cage by horn "G," closed due to action of lever "B."

Cagers

The cagers, known as the Nolan Cagers, were furnished by the Mining Safety Device Co., and operate as follows (refer to figure 1):

A shoe on descending cage comes in contact with and moves bell crank "A," which revolves shaft with cranks and links connected to horns "B" and "C," "B" being thrown out and releasing car in front to run on cage while "C" is thrown in and holds remaining cars back.

When cage ascends counterweight "D" turns shaft so that "C" is opened and cars move up and are held by horn "B" until cage returns again. These horns are mounted with buffet springs on 60-lb. rails 16½ ft. long which are on a grade of 5½ percent so that released cars will have sufficient momentum to push empty cars off of cage and operate mechanism on cage. The grade above cagers is 1¼ percent or just sufficient to keep cars moving by gravity.

These cagers are well made and are giving fine service. At one time a trip of cars got away and headed into shaft at a high rate of speed. These cagers withstood the shock without any damage to themselves, but journal boxes and wheels were sheared off of the first two cars. When the wrecked cars were cleared away we went ahead as usual.

In conclusion I might state that this installation has been very satisfactory, and in electrifying one of our outlying mines we are duplicating this equipment.

Views showing the Page mine, left, and the Page mill

THE FEDERAL MINING AND SMELTING COMPANY PAGE MILL

Mining And Concentrating Practice For Galena And Sphalerite—Mine Closed 15 Years Ago As Concentrating Methods Then In Use Not Successful—Oil Flotation Concentrates Lead-Zinc Ore And Operation Is Profitable

By H. G. WASHBURN *

THE Page mine was developed in 1909 and in 1910, but owing to the fineness and intimate mixture of galena and sphalerite in the ore, it was found that it could not be successfully treated by metallurgical methods in use at that time, and the mine was shut down.

In the Spring of 1925 the Federal Mining and Smelting Co. reopened the property and after doing additional development work, built a 250-ton, all-flotation mill, a surface plant at the mine, and the necessary camp accommodations. The construction work was done during the summer and fall of 1926, and the mill was put in operation December 7, 1926.

The mill is located on Silver Creek, Shoshone County, Idaho, and is three miles west of Kellogg and about one mile south of the Yellowstone Highway.

The ore from the mine stopes is hauled in 2-ton, side-dump cars, by electric storage battery locomotives, and, after weighing, is dumped into a 250-ton skip pocket. It is then hoisted in a 2-ton skip, the shaft being 600 feet on a 50-degree incline, and automatically dumped into a 170-ton bin at the shaft collar. From this bin the ore is hauled 500 feet to the 150-ton mill coarse ore bin, in 2-ton "A" dump cars drawn by a trolley type electric locomotive.

The mine ore is drawn from this bin, and after passing over a 1-in. grizzly shaking feeder, is crushed to a maximum size of 1½ in. by a Gates No. 4 gyratory crusher. The crusher discharge and the undersize from the shaking feeder join, and drop direct to a 200-ton fine ore bin, after having a 1/25 sample cut taken by a bucket and chain type automatic sampler.

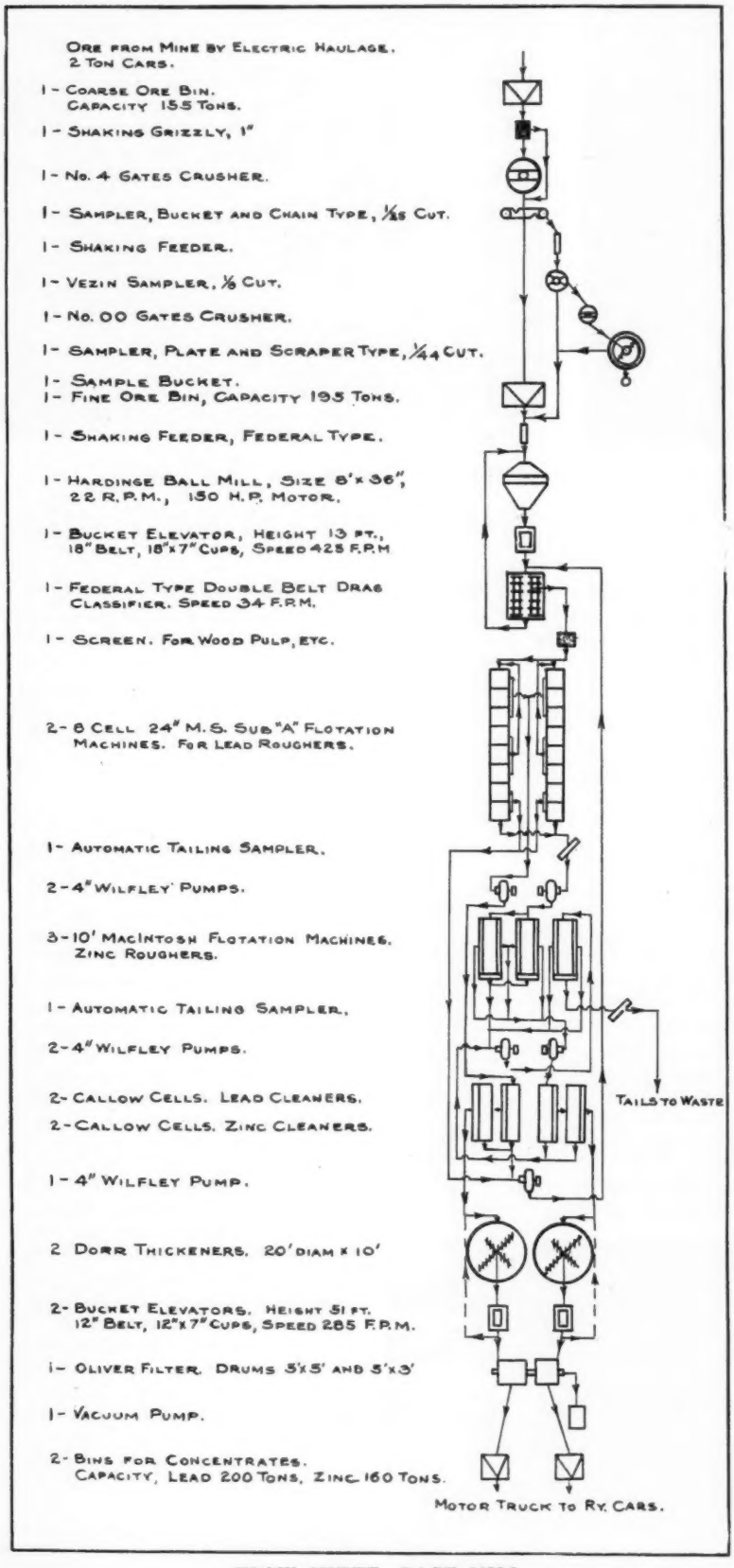
The sample cut is discharged on a shaking feeder which in turn discharges to a Vezin sampler taking a ⅛ cut. The sample cut is then crushed to a maximum size of ⅜-in. by a No. 00 Gates crusher, the crusher discharge going direct to a plate and scraper, Bunker Hill type sampler taking a 1/44 cut. All rejects from samplers go direct to the feeder for the Hardinge Mill.

From the fine ore bin the ore is fed by a Federal type shaking feeder to an 8-ft. by 36-in. Hardinge ball mill, the discharge of the mill going by way of an 18-in. bucket elevator to a Federal type double belt drag classifier, operating in closed circuit with the Hardinge mill. The overflow from the classifier, 70 percent minus 100 mesh, and with a liquid to solid ratio of 3½ to 1, goes over a stationary flat screen to remove all wood pulp, etc., and is split to two 8-cell standard 24-in. Minerals Separation Sub A flotation machines. The first three cells of each of these machines make a rougher lead concentrate that is recleaned on two Callow cells, the cleaner lead tails going back to the drag classifier. The fourth, fifth and sixth cells of each M. S. machine make a low-grade concentrate that is returned to the head of the machine, and the seventh and eighth cells a very low-grade concentrate that is returned with the lead cleaner tails to the drag classifier. The tails from the lead machines are automatically sampled and then split over two 10-ft. MacIntosh flotation cells for zinc flotation. Each cell makes a rougher zinc concentrate that is recleaned on two Callow cells, the cleaner zinc tails going to the head of the zinc circuit. The tails from the two MacIntosh cells join and go to a third MacIntosh cell, this making a low-grade concentrate that is returned to the head of the zinc circuit, and a tailing that is automatically sampled and then goes to waste by way of a tailing flume one mile in length. The air for the M. S., Callow and MacIntosh machines is furnished by a No. 5 Root's blower.

The lead and zinc concentrates from the Callow cells go separately to two Dorr thickeners, 20 ft. diameter by 10 ft.

Rooming and boarding houses, Page mine camp

* Assistant General Manager, Federal Mining & Smelting Co., Wallace, Idaho.



FLOW SHEET—PAGE MILL
FEDERAL MINING & SMELTING CO.
CAPACITY 250 TONS

deep. The thickened concentrate goes by separate 12-in. bucket elevators to a new type double drum Oliver filter. The drum filtering the lead concentrate is 5 ft. by 5 ft., and the drum filtering the zinc concentrate is 5 ft. by 3 ft. The filtered concentrate, averaging 8 to 9 percent moisture, is discharged direct to two storage bins, the lead bin having a capacity of 200 tons, and the zinc bin 160 tons.

The concentrate is drawn from the bins into motor trucks and hauled 3 miles to a railway siding, on the Oregon-Washington R. R. & N. Co., just west of Government Gulch, and is loaded in box cars for shipment to the smelters. The lead concentrate goes to East Helena and the zinc concentrate to Great Falls.

Oils and reagents used are as follows:

	Lbs.	
For lead flotation:		
Zinc sulphate	1.46	per ton of ore
No. 1 Cleveland Cliffs hardwood creosote	.276	per ton of ore
Sodium xanthate	.20	per ton of ore
For zinc flotation:		
Copper sulphate	1.80	per ton of ore
Sodium xanthate	.13	per ton of ore
Barrett No. 4 oil	.12	per ton of ore

The mill has a capacity of 250 to 275 tons per 24 hours, and employs 10 men per 24 hours. Approximately 350 horsepower is required. Concentration ratio: Lead, 10:1; zinc, 33:1.

Average assays of mill feed and products are as follows:

	Silver Oz.	Lead Pct.	Zinc Pct.
Mill feed	2.20	6.75	2.90
Flotation lead concentrates	18.00	61.00	9.0
Flotation zinc concentrates	4.00	3.50	52.00
Final mill tails	0.30	0.75	0.50
Average total recoveries	87.0	88.0	83.0

TO STUDY HYDRAULIC MINING

The Mineral Resources Section of the Commonwealth Club of California has undertaken a study of the question of the rejuvenation of hydraulic mining in the state. An organization meeting was held on August 10, 1927, and provisional dates set for the discussion of various angles of the problem. At a meeting August 24, the proposed plan for the rehabilitation of hydraulic mining was outlined. On later dates meetings will be held at which the agricultural, navigation, irrigation, and power interests will present their side of the argument. The section on mineral resources will act as a fact-finding commission and present its findings to the Commonwealth Club. It is hoped that this will serve to clear up differences between the interested parties.

Walter Stalder, consulting petroleum geologist, is chairman of the section on mineral resources. Walter W. Bradley, of the State Mining Bureau, and Abbott A. Hanks, chairman of the subcommittee on placer mining, will assist in conducting the proceedings.

THE NATION'S VIEWPOINT

A Digest Of The Expressed Opinions Of Leaders In American Affairs

Hon. Ogden L. Mills, *Undersecretary of the Treasury,* at the Institute of Public Affairs, University of Virginia, August 10, again rapped state and local taxation policies. Emphasizing the fact that "the tax problem in the United States is no longer one of Federal, but rather of state and municipal finance," he said in part:

"Ever since the war the attention of the taxpayers has been fixed on Washington, their insistent demands for relief have been aimed at the Federal Government, and the results have been eminently satisfactory. Expenditures have been reduced to bed rock, and taxes cut to a point where, either from the standpoint of rates or of total volume, they no longer constitute an excessive burden for a nation as rich as ours.

"That this satisfactory condition will in the main continue for the immediate future at least, is subject to one important reservation. Federal expenditures will not be held down if the recently instituted practice of giving aid to the states is broadened to cover an ever-widening field of activities, a practice which is being strenuously and persistently urged by special groups striving for immediate results by go-getter methods, and which is open to two very serious objections: First, it makes it difficult to measure the true cost of Federal functions; and, secondly, and most important, it undermines the most fundamental and the soundest principle of our whole governmental structure, that of home rule, with all that it spells in the way of responsibility and of local and individual self-reliance. *Centralization in the United States is the enemy of good government.*

"But, while our eyes have been turned to Washington and we have been voicing our satisfaction over the accomplishments there, we have failed to note what was happening at home. Gratified with the steady reduction in the cost of the Federal Government, we have been neglectful of the fact that the costs of state and local governments were rising so steadily as to offset and wipe out practically all of our gains. Far from being lower, our total taxes were actually higher in 1926 than in any preceding year, except 1920 and 1921, and only 227 millions lower than the peak year 1920.

©Kansas City Times

The End of Another Rose Tinted Dream

Washington Post

Work Waits for the Whistle

"While Federal taxes were reduced from 4,905 millions in 1921 to 3,417 in 1926, or a reduction of 1,488 millions, state and local increased from 3,933 millions to 5,348 millions, or an increase of 1,415 millions. One is almost tempted to say, "What's the use?" Between 1921 and 1926 state taxes increased 61 percent and local 30 percent while Federal taxes declined 30 percent.

"The difference between the rate of increase of state and local taxes is easily explained by the larger contributions made by the states to functions once almost exclusively financed locally, such as education and the construction and maintenance of highways.

"Federal taxes amounted per capita to $27.17 in 1926, as compared with $45.23 in 1921; and per person gainfully employed to $76.61 in 1926 and to $120.16 in 1921. State and local taxes were $36.27 per capita in 1921 and $45.66 in 1926; $96.35 per person gainfully employed in 1921, and $119.92 per person gainfully employed in 1926.

"The Congress just at present is very much concerned with agricultural legislation looking to improved methods of marketing and better prices for the farmer. I do not want to minimize what can be accomplished along those lines, but I do want to suggest that the farmer can do something to help himself at once by demanding of his state and local officials economy and reduced taxes.

"As a result of economy in Washington, the rates of a fairly well devised and reasonably scientific tax system are coming down; while, on the other hand, those of an unbalanced and unfair state and local system are rising, increasing existing inequalities and injustices.

"Considering taxation in relation to national income, which, after all, is one of the most important factors in estimating the weight of the burden, we find that Federal taxes took 3.8 percent of our total national income in 1926 as compared with 7.7 percent

in the peak year 1920. On the other hand, we find that state and local taxes combined took 6 percent in 1926 as compared with but 4.4 percent in 1920.

"While, on the one hand, the Federal Government is paying off its indebtedness, the states and municipalities are not only exhausting their tax revenues, but are resorting to bond issues to finance additional expenditures, apparently neglectful of the fact that in the long run borrowing is the most expensive method of public financing.

"From January, 1913, to June, 1927, the net indebtedness of state and local governments increased from $3,364,000,000 to $11,703,000,000. In the meanwhile, the national debt has been diminished from $25,482,000,000 on June 30, 1919, to $18,512,000,000 on June 30, 1927.

"We find, then, by studying all of these figures, that the Federal Government has been steadily reducing expenditures, taxes and the national debt, but that, on the other hand, all that they have succeeded in accomplishing in these three directions has been about wiped out by the upward tendency of expenditures, taxes and borrowings of state and local governments.

"If we study the gross expenditures of state and local governments, we find that in 1925, out of a total of 7,343 million dollars, 29 percent was spent for education, 20 percent went for highways, 12.5 percent for social welfare, 11.6 percent was devoted to debt service, 9.7 percent went to defray the cost of protection of persons and property, 6.8 percent was expended for public service enterprises, and 6.5 percent for overhead.

"I want to call attention to the fact that debt service constitutes a considerable item in the total amount of state and local expenditures, and that the sum expended for interest and debt retirement in 1925 was about two-thirds the value of the total bonds issued that year. In other words, states and localities have made such free use of the borrowing power that the billion and a third of bonds which they sold in 1925 left them no very great margin over the amount they were obliged to pay for debts already incurred.

"The taxation problem in the United States today must be solved in our state capitols, city halls and county seats. There is need of a solution. The cost of government is too high. The solution will be found if the people apply to their local governments the same insistent pressure that they have applied to their Federal Government since the close of the war period; but pressure alone will not suffice. The pressure must be of a discriminating and intelligent character, and this implies, on the part of the Government, a budget system that will enable the people to get a correct picture of the financial transactions and status of their Government, and, on the part of the people, a willingness to devote to their Government that intelligent consideration and active interest without which, in the long run, no popular government will function adequately, or, for that matter, endure."

Washington Evening Star

Just Waiting to Hop Off

Cincinnati Enquirer

Yep, If It Doesn't Blow Up A Storm

Philadelphia Public Ledger

Which Way?

Commenting on the resale price investigation of the Federal Trade Commission, **Gilbert H. Montague** of the New York bar, says:

"Nothing that the Federal Trade Commission today could possibly do could excite more interest than the Commission's present proposal to investigate all the economic, legal and business angles of resale price maintenance and resale price cutting.

"For 10 years, the courts have been working further and further into the fog.

"Last May, in the American Tobacco case, the Supreme Court of the United States in effect served notice that it could give no further enlightenment on this subject.

"Several Circuit Courts of Appeals have, in recent years, judicially expressed the extreme difficulty they have experienced in understanding and applying hair-line distinctions that now separate lawful from unlawful resale price maintenance.

"All this has, in recent years, greatly augmented resale price cutting and enormously increased the difficulties of manufacturers, distributors and dealers whose best advertised lines are the subject of this price cutting.

"Nobody in the country, outside these manufacturers, distributors and dealers themselves, has had closer contact with this subject than the Federal Trade Commission, for the Commission is the governmental body that today is primarily charged with the duty of enforcing the present law against illegal methods of resale price maintenance.

"That the Federal Trade Commission should, in spite of all this, be willing to investigate the economic, legal and business angles of the very law that it now is enforcing is an extraordinary instance of broad-mindedness and good sportsmanship."

Chino Mines at Santa Rita, New Mexico

THE CHINO MINES MEETING OF THE NEW MEXICO CHAPTER

Notable Gathering Of Mining Men In New Mexico Addressed By Secretary Callbreath—Technical Papers Discussed—Visit Mines Near Silver City, Hurley And Santa Rita, And See Creek Diversion That Releases Ten Million Tons Of Ore

AT the spring meeting of the chapter, held in Socorro the latter part of April, Mr. John M. Sully, general manager of the Chino Mines of the Nevada Consolidated Copper Company, extended an invitation to the members of the New Mexico Chapter to hold a meeting at Santa Rita and Hurley as guests of the company. The opening of the flume for the diversion of Santa Rita Creek, just completed by the Chino Mines of the Nevada Consolidated Copper Company at Santa Rita, N. Mex., was the occasion for the meeting, which was held at Santa Rita and Hurley on July 25 and 26.

The program for the meeting was arranged by the committee under the chairmanship of Mr. R. B. Tempest, assistant general manager of the Chino Mines, and covered two days. Members and guests met at the Club House at Hurley for registration and a "Get Acquainted" meeting. Lunch was served at the guest house, at which time a talk was given by Mr. Ira L. Wright, manager of the Black Hawk Consolidated Mines Company, on the "Mining Industry in Grant County." Following the luncheon, members and visitors were divided into small groups and conducted through the power plant, concentrating mill, machine shops, foundry and other operations allied with the enterprise at Hurley.

Later in the afternoon, the party, 100 in number, consisting not only of members and visitors from New Mexico, but also members from the Arizona Chapter, were taken in automobiles to Santa Rita.

In the building of the flume for the diversion of Santa Rita Creek, it became necessary to discontinue the direct highway then in use. After the last of the automobiles had passed over the road, Mr. Sully set off a round of shots which made the road unavailable for use, making Santa Rita inaccessible from the west, except by means of another road through what is known as "Lover's Lane." This road will be in use until the new road, which will parallel the flume, is completed. Members of the party were much interested in the operations of the 350 Model electric power shovel, that will not only cut out the blasted road, but will shortly cut through the old creek bed.

After the firing of the blast, members boarded flat cars, which had been provided with benches, and were taken for a trip around the workings of the mine. The first portion of this trip was along the railroad track paralleling the newly constructed flume, and the magnitude of the undertaking became apparent for the first time and it was understood why this engineering work had required the removal of 790,000 cubic yards of bench stripping, 50,300 cubic yards of Channel excavation, 40,350 cubic yards of grading for Santa Fe depot and yard changes, and 11,530 cubic yards of concrete, and that the total cost, involving road changes, removal of the Santa Fe Railroad depot and yard changes, exceeded $800,000. The entire length of the flume is 7,500 feet, the section being designed to handle 5,250 cubic feet of water per second. The total time for construction has been about two years. The ore released by the diversion of Santa Rita Creek from its old channel amounts to over 10,000,000 tons.

After traversing the flume grade, the observation cars proceeded on their way by the large crushing plants at Santa Rita, where the coarse material, loaded by steam shovels, is given a primary crushing before being sent to the mill at Hurley. The train proceeded around the top of one of the high dumps and then close to Santa Rita Mountain on to one of the high benches, 6,400 feet above sea level, giving the passengers a wonderful view of the pits and flume construction. From this shovel bench the train returned to Santa Rita.

All of those attending were guests of the company at a dinner held in the club house at Santa Rita, and each was presented with a specimen of native copper from the Chino Mines, mounted on a card bearing an appropriate legend. Immediately following the dinner, a dance was held on the tennis court.

On the morning of the 26th a meeting was held in the Club House at Santa Rita, the principal address being made by Mr. J. F. Callbreath, secretary of the National Organization. Mr. Callbreath, in his address, gave the members an insight into the purposes and accomplishments of the National Organization of the American Mining Congress, and brought home to those attending, the importance of the work being done. After Mr. Callbreath's address the following technical papers were read:

Concentrator, Water Supply and Power Plant at the Hurley Plant, *J. T. Shimmin, Supt. of Mills.*

Mining Methods at Chino Mines, *H. A. Thorne, Supt. of Mines.*

Diversion of Santa Rita Creek, *C. F. Ames, Mechanical Engineer.*

Mining Methods of the Hanover Bessemer Iron and Copper Co., Fierro, N. Mex., *L. M. Kniffin, Manager.*

Rock Dusting and Other Safety Methods Used at No. 5 Mine of Gallup American Coal Co., Gallup, N. Mex., *Horace Moses, Manager, and L. M. Kuhns, Safety Engineer.* (*Cont. on page* 746)

AMERICAN MANGANESE PRODUCERS ORGANIZE

Claim Made That Large Developments In Manganese Have Gone Forward Under Encouragement Of Tariff, Including Development Of Successful Processes In Beneficiation Of Low Grade Ores

ON August 2 the first national meeting of manganese producers of the United States was held in Washington for the purpose of considering ways and means to encourage and increase the development and production of domestic manganese ores and to make plans for better cooperation with the United States Geological Survey, the Bureau of Mines and the United States Tariff Commission in assembling data on the present status of the manganese industry. J. Carson Adkerson, Vice President Hygrade Manganese Company, Woodstock, Va., presided.

The meeting resulted in the organization of the American Manganese Producers Association, described in its by-laws as "an organization to further the production, beneficiation, and use of domestic manganese-bearing ores."

The following were elected officers, directors and members of the Executive Committee:

DIRECTORS

Richard H. Brown, President, Manhattan Electric Supply Company, New York City, *Chairman.*

A. J. Seligman, President, Butte Copper & Zinc Company, New York City.

J. Carson Adkerson, Vice President, Hy-Grade Manganese Company, Inc., Woodstock, Va.

John H. Cole, President, Domestic Manganese Development Company, Anaconda, Mont.

W. B. Daly, General Manager Mines, Anaconda Copper Mining Company, Butte, Mont.

Joel Hurt, Jr., President, Georgia Minerals Co., 201 Hurt Building, Atlanta, Ga.

H. A. Pumpelly, Vice President, Domestic Manganese Development Company, New York City.

N. H. Mannakee, Bluefield, W. Va.

D. H. McCloskey, Brown Mountain Mining Company, Staunton, Va.

L. B. Miller, Cleveland, Ohio.

Carl Zapffe, Northern Pacific Railway Company, Box 93, Brainerd, Minn.

John A. Savage, John A. Savage Company, Duluth, Minn.

W. C. Siderfin, Vice President, Clark Montana Realty Company, Butte, Mont.

Chas. W. Massie, Secretary-Treasurer, Hy-Grade Manganese Company, Woodstock, Va.

F. N. Hicks, Chicago, Milwaukee & St. Paul Railway, Seattle, Wash.

John Hickey, President, Moonlight Mining Company, Philipsburg, Mont.

E. A. Fritzberg, Superintendent, Trout Mining Company, Philipsburg, Mont.

W. G. Rinehart, Batesville, Ark.

E. F. Hummel, Chicago, Milwaukee & St. Paul Railway, Butte, Mont.

P. G. W. Shook, Treasurer, Arkala Manganese Ore Company, Birmingham, Ala.

C. G. Ewing, President, Philipsburg Mining Co., St. Louis, Mo.

H. O. Flickinger, President, Silver Prince Mining Co., Philipsburg, Mont.

OFFICERS

Richard H. Brown, *Chairman of Board of Directors;* J. Carson Adkerson, *President;* John H. Cole, *First Vice President;* H. A. Pumpelly, *Secretary;* A. J. Seligman, *Treasurer.*

EXECUTIVE COMMITTEE

J. Carson Adkerson, *Chairman,* Richard H. Brown, A. J. Seligman, H. A. Pumpelly, D. H. McCloskey.

In his opening address Chairman Adkerson said that representations are being made that there is practically no manganese ore in the United States, and the general impression unfortunately prevails that there is none. He said that opponents to the tariff claim that our total reserve of ferro grade ore is only 1,493,200 tons and that they failed to show that the mines of the United States have already shipped more than this amount of high grade manganese ore, which has hardly scratched the known deposits; also that they failed to show various developments have gone forward under the encouragement of the tariff which and in many instances have shown reserves ten to fifty times greater than was admitted to exist.

J. Carson Adkerson

Continuing, he said: "Application has been made to the Tariff Commission for a reduction in the tariff on manganese ore. The Tariff Commission has the authority to recommend to the President a 50-percent decrease or increase in the tariff and the President has the authority to act on the recommendation of the Commission. The Tariff Commission has made its preliminary investigation from the data it has at hand and has started a full investigation of the manganese situation covering the supply and domestic costs of the production of ore, ferro manganese, spiegeleisen, and manganese-bearing materials. The present investigation is to cover the general situation. If this investigation checks the preliminary investigation and the findings of the Tariff Commission indicate that action should be taken on the tariff then report will be made and open hearings scheduled which will permit persons pro and con to submit further evidence both oral and written. Following this recommendations to the President will be made. If evidence can be presented to the Tariff Commission at the present time sufficient to establish to the satisfaction of the Commission the advisability of the tariff then it can be expected the Commission might soon conclude its investigation and no further action would be taken.

"Evidence of the following nature would probably serve to satisfy the Tariff Commission:

"1. Reserves of suitable manganese ore greater than have been reported.

"2. Developments worthy of notice since the tariff.

"3. Activity in the fields.

"4. Substantial strength of parties interested in the developments and in the tariff.

"5. Substantial amounts of money being spent in the developments.

"6. Assurance of an increase in production.

"7. Assurance of an increase in reserves being developed and discovered.

"8. Demand for the tariff by enough interested parties.

(*Continued on page* 746)

NEWS OF THE MINING FIELD

A Resume Of The Activities Of The Mining Industry And Items Of Interest In The Field

Anaconda Erecting New Plant to Treat Slag

The Anaconda Copper Mining Co. has begun construction on ground leased from the American Smelting & Refining Co. and adjacent to the East Helena plant, of the first unit of its two-unit plant for treating of the slag pile, and current slag from the East Helena smelter. The unit will include a furnace, combustion chamber, flues, baghouse, compressor plant, and coal pulverizing equipment, according to J. R. Hobbins, vice president of Anaconda.

It is planned to treat 200 tons a day of molten slag, he said, making from the slag zinc-lead oxide suitable for treatment at Anaconda's electrolytic zinc plant at either Great Falls or Anaconda. In case results at the present unit are as good as expected the capacity will be increased to 500 tons a day. The first unit is expected to be in operation October 1. The plant will employ 40 men, while increased capacity would require 100 men.

Montana Section, A. I. M. E., for More Funds for Mining Bureaus

At a meeting of the American Institute of Mining and Metallurgical Engineers held at Butte, it was unanimously voted that the Montana section draft resolutions to be presented to President Coolidge, Secretaries Hoover and Work, and to the four Montana representatives at Washington asking that the Bureau of Mines and the Geological Survey be allowed better appropriations. Figures were presented showing that Government appropriations to various departments of agriculture last year totaled $127,000,000, against $3,000,000 for the mining departments.

After the business meeting C. P. Woodard, of the mechanical department of the Anaconda Copper Mining Company, gave a detailed description of the new hoist now in operation at the Belmont mine, Butte.

Machinery for Butte Manganese Plant

The machinery to equip the Butte plant of the Domestic Manganese and Development Company will arrive about September 15, according to W. C. Siderfin, Butte, and John H. Cole, of Anaconda. The plant will be of 250 tons per day capacity and will be principally devoted to concentrating the "pink" manganese ores of this district. The U. S. Geological Survey will send two field men to Butte to help determine manganese possibilities of the district.

Hoist Installation at Cole Shaft of C. & A. Completed

The new motor-driven hoist installation at the Cole Shaft of the Calumet and Arizona Mining Company, Warren, Ariz., is now complete. The hoist is of Allis-Chalmers make. It is driven by a 350 H. P. motor and has a capacity lift of 2,200 feet.

The new installation at the Cole Shaft was put in preparatory to an active exploratory campaign in this section of the district. Reconditioning of the shaft will begin at once and, as soon as it is completed, exploratory drifts will be started.

New Mill at Gunsight Mine

The erection of a small flotation mill at the old Gunsight mine is planned. The Gunsight mine is in Pima County, Arizona, about 24 miles east of Ajo. It was at one time a producer of silver lead ores, but has been inactive, except for minor work by lessees, since 1892.

During the past year enough ore has been developed to warrant the erection of a small mill. A small electric power plant will also be built.

Work Resumed at Quincy Mine

Work has been resumed in the Quincy mine, Houghton, Mich., after a shut down since July 13 due to fire in No. 2 shaft. Hoisting has been started in No. 6 shaft and timbermen are at work in No. 2. Three shifts of timbermen will be employed and repair work probably will take several months. The fire damage in No. 2 is above the 53rd level. It will be possible to work three or four levels above the 86th in No. 2 through No. 6 shaft. The U. S. Bureau of Mines car, which had been at the mine since the outbreak of the fire, left for Duluth, the work of its engineers having been completed.

Quincy has lost one month's full production on account of the fire, and output during the remainder of the year will be considerably curtailed owing to the necessity of extensive repairs in No. 2.

Mining Companies Must Pay Royalty Tax

The Supreme Court of Minnesota early in August handed down an opinion reversing the decision of the lower court and apparently making the payment of the 6 percent royalty tax obligatory on the mining companies. The court held that in the final analysis "the royalty tax is imposed upon the right, title and interest of the lessor in ore lands for the purpose of mining the ore for a royalty. And where the lessee (or

MINE PRODUCTION OF GOLD, SILVER, COPPER, LEAD, AND ZINC IN UTAH IN 1926, BY COUNTIES

(In terms of recovered or recoverable metal)

Advance figures by V. C. Heikes, of the United States Bureau of Mines

County	Number of producers	Ore treated Short tons	Gold* Fine ounces	Silver* Fine ounces	Copper Pounds	Lead Pounds	Zinc Pounds	Total value
Beaver	11	38,511	1,028.79	203,907	259,767	4,180,434	128,450	$528,941
Box Elder	2	239	62.50	6,683	16,550	13,317	.....	8,844
Cache	1	3	.....	2	.....	2,174	.....	175
Garfield	1	.....	1.50	.....	.....	.....	.....	31
Iron	1	21	11.85	64	16	.....	.....	287
Juab	27	407,974	31,443.27	5,088,183	4,624,011	50,008,509	8,370,778	9,100,867
Millard	3	453	.....	614	.....	87,617	.....	7,392
Morgan	1	260	.39	805	.....	75,656	.....	6,564
Piute	3	594	399.97	6,082	3,640	55,528	.....	17,015
Salt Lake	44	14,534,263	120,779.07	3,738,505	249,429,794	113,299,672	51,167,288	52,651,244
San Juan	1	.....	14.66	1	.....	.....	.....	304
Summit	11	395,290	4,047.29	2,978,197	1,139,615	38,943,342	10,963,436	6,039,331
Tooele	41	40,537	2,478.83	204,749	179,780	11,071,103	2,368,563	1,267,504
Utah	16	139,655	7,517.67	3,488,169	671,643	44,656,739	107,524	6,006,655
Wasatch	3	298,389	14,977.19	3,642,620	1,139,666	32,875,934	22,073,341	7,027,730
Total, 1926	166	15,856,144	182,762.98	19,358,581	257,464,482	295,270,025	95,179,380	†82,662,884
Total, 1925	179	14,479,247	177,803.08	21,276,689	236,486,540	306,669,824	52,611,732	‡82,701,394

* Includes placer production.

† Average value of metals: Gold, $20.671835 per ounce; silver, $0.624 per ounce; copper, $0.14 per pound; lead, $0.08 per pound; zinc, $0.075 per pound.

‡ Average value of metals: Gold, $20.671835 per ounce; silver, $0.694 per ounce; copper, $0.142 per pound; lead, $0.087 per pound; zinc, $0.076 per pound.

operator) has covenanted to pay all taxes and assessments, ordinary and extraordinary, general and specific, upon the demised land, he must pay the royalty tax."

This tax was passed by the Minnesota legislature in 1923 and is a levy of 6 percent on royalty received for permission to explore for, mine and remove iron ore from lands within the state. This tax is in addition to the ad valorem tax and the occupational tax, both borne by the mining companies in Minnesota.

The cases of Belle L. Marble vs. Oliver Iron Mining Co., James H. Flynn vs. Minnesota Iron Co., George Fletcher vs. Lorain Iron Mining Co., and Mississippi Land Co. vs. International Harvester Co., were argued before Judge E. J. Kenney of the district court of Duluth last fall. Judge Kenny sustained the demurrer of the defendants and held that the fee owner could not collect from the lessee money paid under the royalty tax. And by implication the royalty tax was to be paid by the lessor or fee owner and not by the lessee or operator. An appeal was made in the cases to the supreme court which reversed the order of the district court.

The mine operators have filed a motion for a rehearing before the supreme court of Minnesota. The motion is made on the strength of certain points which have not been stressed by the court, and which the operators would like to have considered more fully. It is expected that a rehearing will, if granted, bring out some further interesting and important angles to the now celebrated royalty tax case.

Developing in East Park City District

The Star of Utah Company, operating in the East Park City district, Utah, is pushing development on one of the largest undertakings in that section since the Park Utah Consolidated first developed the district. In that section the company has approximately 1,140 acres under its control which it is prospecting with a long development tunnel.

The drift is now in the side of the mountain approximately 600 ft., having cut numerous fissures and stringers with some ore showings. The company, however, is content to leave these and push development for the old Wabash claims, which were productive years ago before the mine was flooded.

United Verde Builds Model Homes

The United Verde Copper Company is building a group of model homes for employes at Clarkdale, Ariz. The group includes a six-room house for the superintendent and nine other houses for employes. All are of Spanish type.

Tungsten Production Company Purchases Additional Properties

The Tungsten Production Company of Boulder, Colo., has closed a deal to take over two large tungsten properties, one in Nevada, covering the Nightingale tungsten district, and the other in Arizona on what is known as the Tungsten Reef Mine in Cochise County. The Tungsten Production Company has been gradually adding to its holdings in the Boulder field.

OCTOBER MEETING OF ARIZONA CHAPTER OF AMERICAN MINING CONGRESS IN GLOBE-MIAMI DISTRICT

THE ARIZONA CHAPTER of the American Mining Congress will hold its fall meeting in the Globe-Miami district on October 10th and 11th. The business meeting of the Arizona Chapter will be held on Monday morning. This will be followed by discussion of operating problems. Papers will be presented on various phases of operation at Miami, Inspiration, Old Dominion and Magma mines.

Visitors will be given ample opportunity for the inspection of the mines and mine plants of the district.

Entertainment will include a banquet at the Cobre Valley Country Club on the evening of the 10th and a Golf Tournament on the following afternoon.

The general committee of arrangements for the meeting follows: Clyde Weed, General Chairman, H. W. Aldrich, Guy H. Ruggles, H. A. Leidich, D. L. Forrester, J. H. Hensley and H. H. Hunt.

Black Eagle Building Tailing Mill

The Black Eagle Mining Co. is building a tailing plant at the No. 2 mine, in the Tri-State district, to have a capacity of 500 tons each 10 hours. The plant will be equipped with four jigs, eight tables and a ball mill for fine grinding. The slimes will be handled over the flotation plant in connection with the main plant.

The company has a large tonnage of tailings and sands to be retreated.

National Zinc to Build Large Acid Plant

Ground has been broken for the new $500,000 acid plant of the National Zinc Co. to be built southwest of Bartlesville, Okla. It is planned to have the first roasting unit in operation by November 1, and the second about a month later. The acid units will be ready for operation about the same time, according to L. W. Leverett, superintendent of the acid plant.

Bartlesville plant will be completed before the plant at Argentine, Kans., is closed. The plant to be erected at Bartlesville will be the largest in the United States, it is said. The new acid plant will produce 180 tons of sulphuric acid daily, which will be shipped by tank cars to refineries in Texas, Kansas, Arkansas and Oklahoma. The contact method will be used in making the acid, the sulphuric fumes being taken from the roasters and turned into acid.

Velie to Build on Leopard Lease

The Velie Mines Corporation plans to build a modern concentration plant on the Leopard lease, west of Baxter Springs, Kans. The plant will be of 500 tons capacity each 10 hours and will be of the latest type of construction. Frank Weeks, manager of the company has done a lot of experimental work in concentration problems at the Velie-Lion mine, and all features of advantage will be incorporated in the new plant.

A third shaft has been started on the lease in the center of the 80 acres. Nos. 1 and 2 shafts have been connected by cross-cut drifts and a large amount of other drifting in the ore body has been done. The three shafts will supply the new mill with a large tonnage of ore. The development work has proven satisfactory. Aside from the sheet ground ore deposit, which occurs at about 300 feet, an upper run of ore is shown by the drilling to come in around 250 feet, similar in character and richness to the upper runs mined at the Hutcheon.

"G" Pabst Shaft Is Relined

The Oliver Iron Mining Company is relining its "G" Pabst shaft at Ironwood, Mich., on the Gogebic range. When this work is completed the shaft will be absolutely fireproof. It will be concreted from the collar to ledge, and from there to the bottom it will be relined with steel shaft sets and concrete lath. This shaft is approximately 2,200 feet deep.

Open Pit at Chisholm Mine

The Oliver Iron Mining Company is stripping a section of the Chisholm mine property, situated near Chisholm, Minn., on the Mesabi iron range, for open-pit mining. The Chisholm mine has long been operated as an underground mine simply, but there is an area on the north side of the property where the ore comes to within 40 feet of surface. The overburden is being removed from this, and the ore will be mined by steam shovel. It is not yet established whether this ore near surface is detached from the main ore body, or is a part of it. Mining in the new pit will be begun about September 1.

RESOLUTIONS ADOPTED AT WESTERN MEETING

Approving Present Metal Schedules—Favoring Increased Support For U. S. Bureau Of Mines And U. S. Geological Survey—Asking Investigation Of Leasing Act And Mining Laws On Public Domain—Appreciation of Cooperation

THE following resolutions were adopted by the Western Division of The American Mining Congress at their fifth annual meeting held at Salt Lake City, Utah, the week of August 22, 1927:

No. 1

WHEREAS recent proposals to remove or lower tariff duties on manganese and fluorspar ores are now pending before the United States Tariff Commission;

Be it Therefore Resolved, That the Western Division of the American Mining Congress in convention assembled expresses its disapproval of any effort at this time to change or modify the metal schedule established by the Fordney-McCumber Act, believing that under present conditions it is dangerous, disturbing and harmful to the mining industry in general to attempt any changes in duties affecting ores until the whole tariff structure comes up for general revision.

Be it Further Resolved, That the members of the Western Division communicate with their respective senators and representatives in Congress, seeking their cooperation in opposing any modification of the present metal schedule during the coming session of Congress.

No. 2

WHEREAS the mineral industry is being seriously hampered by reason of the reduced appropriations which are made each year for the support of the U. S. Bureau of Mines and for the U. S. Geological Survey, and

WHEREAS according to the testimony given to the Senate Committee on Mines and Mining at a public hearing held on February 9, 1927, it clearly shows that the Bureau of Mines was unreasonably and disproportionately cut to extent of about $600,000 in the interest of other activities of the Department of Commerce, and

WHHEREAS we believe that the splendid work in the way of research and experimentation, which has heretofore been carried on so successfully by the Bureau of Mines and which has been so helpful and valuable to the mining industry, should be encouraged, rather than stifled by lack of funds, and

WHEREAS we believe that the U. S. Geological Survey should be permitted to carry on to completion the topographical mapping of the United States, as provided for in the Temple bill, and to extend its activities in geological mapping, stream gauging and land classification, rather than to curtail such activities by reason of inadequate appropriations, and

WHEREAS the responsibility for these reduced appropriations rests upon the Director of the Budget, the Secretary of Commerce and the Secretary of the Interior, rather than upon Congress,

Now, be it Resolved by the Western Division of The American Mining Congress, in convention assembled in Salt Lake City, August 22-25, 1927, that it is strongly opposed to the present policy, and earnestly requests that those in authority grant more liberal appropriations to the U. S. Bureau of Mines and to the U. S. Geological Survey, to the end that the activities above mentioned may go forward, and not retrogress, and that such appropriations will be more in keeping with the importance of the mining industry, which is one of the great basic industries of this country.

Furthermore, be it Resolved, that copies of this resolution be sent to the President of the United States, the Secretary of Commerce, the Secretary of the Interior, the Director of the Budget, and to the Senators and Representatives in Congress from all the Western States.

No. 3

WHEREAS the administration by the Federal Government of the Leasing Act of 1920 and its construction of the Mining Laws of the United States in connection therewith has entailed great loss and imposed much hardship upon citizens holding claims and leases upon the Public Domain so as to create serious apprehension and dissatisfaction in the mining regions of the West, since disputed questions involving property rights and privileges arising between the United States and such citizens are determined arbitrarily by the administration officials themselves without rights of appeal to the courts of the land, and

WHEREAS such practice and actions by such officials tends to discourage and suppress mining and prospecting enterprises necessary for the future development of our mining industry and to penalize rather than reward the citizen who reaps a discovery of minerals upon the public lands, and

WHEREAS it has been the purpose of our mining laws to encourage rather than discourage mining enterprise and it should be the prerogative of American citizens to have their rights determined before an unbiased tribunal rather than administration officials representing the only other party in interest, and

WHEREAS the mining industry of the West believes that the mining laws existing at the time of the enactment of the Lease Act of 1920 should be preserved and construed in accordance with the statutes and decisions under which they were initiated,

Now, Therefore, be it Resolved, That the Western Division of The American Mining Congress in convention assembled at Salt Lake City, Utah, August 22-25, 1927, respectfully request the National Organization to make a thorough investigation of the administration of the Leasing Act of 1920 and the Mining Laws of the United States in connection therewith through such agency or agencies as it may elect and to make report to the next annual meeting of The American Mining Congress with such recommendations as may be proper for a more just administration of the law and the best interests of the nation.

No. 4

RESOLVED, That the thanks of the convention are hereby extended to the following:

The officers of the American Institute of Mining & Metallurgical Engineers and of The American Mining Congress for their presence and participation and for their assistance in the preparation and presentation of the program.

The Utah Chapter, American Mining Congress; the Utah Section, A. I. M. E.; and the Women's Auxiliary, Utah Section, A. I. M. E., for the arrangements provided for the delegates and their families;

To Mayor C. Clarence Neslen and the citizens of Salt Lake City for their hospitality and interest;

To the press of Utah for the satisfactory manner in which it recorded the proceedings; to the management of the Utah Hotel for the accommodations offered;

To the officers of the convention, the authors of the papers presented and to others who participated in the deliberations.

To the mining companies and mining men of Utah for their many courtesies, which added so greatly to the success of the occasion.

Another Furnace for Hubbell

Calumet & Hecla Consolidated has plans for the construction of another large furnace at its smelting plant at Hubbell, Mich. This will give the company four large units, three for smelting and one for refining. The smelter also is equipped with a modern casting machine. The proposed new furnace will have a capacity of 600,000 lbs. at one charge, and it is understood its construction will increase the smelter's capacity to 20,000,000 lbs. of copper per month. Labor costs have been largely cut through the installation of modern furnaces and equipment at Hubbell. The casting machine is capable of handling 100,000 lbs. of copper in one operation, requiring the services of only two or three men, as compared with the labor of 20 men more than eight hours previously.

Start Stripping Overburden from Crosby Mine

Butler Brothers have started to strip the Crosby mine at Nashwauk, Minn. The Crosby mine has been worked by the underground system of mining and has been idle ever since the Cleveland-Cliffs Iron Company ceased mining here a number of years ago. The last shipment of ore was made in 1922. The fee of the Crosby mine is owned by the Mississippi Land Company, and the Meriden Iron Company is looking after that company's interests on the Mesabi range.

Rolling Mill Mine Shuts Down

Clement K. Quinn & Co. have discontinued operations temporarily at the Rolling Mill iron mine, Marquette range, Michigan. The Archibald iron mine, a new producer for this company, will meet the ore requirements of that property for a time. The company has not abandoned the lease of the Rolling Mill, nor is the property exhausted.

To Rebuild Patrick Washing Plant

The Patrick iron mine washing plant, located 2 miles west of Cooley, Minn., on the Mesabi iron range, which recently was destroyed by fire, will be rebuilt soon. The Patrick plant washes iron ore from the Patrick open pit of Butler Brothers.

Further Development of Ivanhoe Group Planned

The board of directors of the Ivanhoe Copper Company, Bisbee, Ariz., has authorized the sale of 100,000 shares of capital stock at $1 per share to finance further development at the Ivanhoe group near Warren. The property lies between the Warren development group now under development by the Phelps Dodge Corporation and the Bisbee Queen group, which is being developed by the United Verde Extension Mining Company. The Ivanhoe shaft was previously put down to a depth of 375 feet and some lateral work done on the 200 level, but no work has been done in the last three years.

M. J. Elsing, who is in charge of the work at the Bisbee Queen group for the United Verde Extension Mining Company, is a director and manager of the Ivanhoe Copper Company.

Death Calls Albert W. Hudson

Albert W. Hudson, since 1919 in charge of the leaching and precipitation plant at the Copper Queen branch of the Phelps Dodge Corporation, died on July 14. Mr. Hudson was striken with a severe attack of heart trouble while at work at the leaching plant and died the following day.

Mr. Hudson was born in New Zealand in 1874 and came to the United States in 1914. For some years he was employed in the research department of the Phelps Dodge Corporation at Tyrone, Douglas, and Bisbee, and in 1919 he was placed in charge of leaching operations at Bisbee. He made notable contributions to the literature on the leaching of copper ores. With his death the industry has lost one of its leading experts on leaching.

New Fluorspar Company Formed in Youngstown

Youngstown, Ohio, district interests have formed a new fluorspar company to develop property in Livingston County, Ky., acquired recently by purchase. Most of the fluorspar used by steel plants in this area is mined in America, but imported material is used in Pittsburgh, and on Atlantic seaboard because of lower cost.

PERSONAL ITEMS

Howard D. Smith, president of the Consolidated Coppermines Company, recently visited the properties of the company at Kimberly, Nev.

W. A. Deichen, of the engineering department of Butler Brothers, at Nashwauk, has been made superintendent of the Louise open pit mine of the Manganiferous Iron Company on the Cayuna Range.

George Wingfield, well known mine operator, has been appointed a member of the Board of Regents of the University of Nevada.

P. F. Boswell has been made general manager of the Carlisle Mine, near Duncan, Ariz., which is being unwatered and developed by the United Metals Corporation.

H. DeWitt Smith, assistant managing director of the United Verde Copper Company, was a recent visitor in San Francisco.

B. L. Thane, mining engineer of San Francisco, has returned from New York.

Lee L. Fillins, former manager of the Anna Beaver Mine, Cardin, Okla., is making a trip through the western states in the course of which he will visit several western zinc and lead properties.

MINE PRODUCTION OF GOLD, SILVER, COPPER, LEAD, AND ZINC IN IDAHO IN 1926, BY COUNTIES

(In terms of recovered or recoverable metal)

Advance figures by C. N. Gerry, of the United States Bureau of Mines

County	Number of producers	Ore treated	Gold *	Silver *	Copper	Lead	Zinc	Total value
		Short tons	Fine ounces	Fine ounces	Pounds	Pounds	Pounds	
Ada	2	1	6.34	1	.....	.....	.....	$132
Adams	1	.....	.97	.....	.....	.....	.....	20
Bear Lake	1	1	.....	1	.....	735	.....	60
Bingham	1	.....	.53	.....	.....	.....	.....	11
Blaine	20	981	49.58	65,255	5,573	580,592	3,838	89,259
Boise	21	5,559	3,955.96	8,702	3,060	82,039	.....	94,198
Bonner	7	3,868	167.96	143,023	39,448	967,468	.....	175,638
Bonneville	3	2	38.70	2	.....	.....	.....	801
Boundary	1	23,572	.....	58,677	2,518	3,193,885	.....	292,477
Butte	8	1,781	2.13	6,958	1,637	523,510	.....	46,496
Camas	2	15	20.32	6	.....	.....	.....	424
Canyon	1	.....	.82	.....	.....	.....	.....	17
Cassia	2	43	26.70	393	551	29,284	.....	3,217
Clark	1	130	.10	196	.....	41,553	.....	3,448
Clearwater	4	.....	40.39	7	.....	.....	.....	839
Custer	15	21,539	356.96	146,116	262,769	4,015,340	67,730	461,650
Elmore	10	183	3,566.49	1,190	.....	.....	.....	74,469
Gem	2	1	4.06	1	.....	.....	.....	85
Idaho	22	342	659.74	223	.....	.....	.....	13,77[illegible]
Jerome	2	.....	11.27	1	.....	.....	.....	234
Kootenai	1	3	.....	11	.....	685	.....	62
Latah	2	.....	14.61	.....	.....	.....	.....	302
Lemhi	28	24,153	637.68	158,784	59,155	5,874,008	9,638	591,189
Owyhee	13	621	190.06	13,848	265	3,028	.....	12,849
Power	1	.....	8.32	.....	.....	.....	.....	172
Shoshone	62	1,859,519	3,441.11	6,952,074	962,447	257,667,986	52,533,485	29,097,421
Twin Falls	3	.....	53.99	3	.....	.....	.....	1,118
Valley	7	827	383.76	968	19	99	.....	8,548
Washington	3	2	30.72	4	.....	.....	.....	638
Total, 1926	246	1,934,143	13,669.27	7,556,444	1,337,442	272,980,212	52,614,691	†30,969,551
Total, 1925	275	1,827,715	20,886.92	7,743,439	3,297,443	253,041,790	31,237,240	‡30,662,621

* Includes placer production. † Average value of metals: Gold, $20.671835 per ounce; silver, $0.624 per ounce; copper, $0.14 per pound; lead, $0.08 per pound; zinc, $0.075 per pound. ‡ Average value of metals: Gold, $20.671835 per ounce; silver, $0.694 per ounce; copper, $0.142 per pound; lead, $0.087 per pound; zinc, $0.076 per pound.

National Fuel Meeting at St. Louis

A meeting of exceptional importance to American engineers and executives, and to all those interested in the use and conservation of fuels, has been arranged by the Fuels Division of the American Society of Mechanical Engineers to be held in St. Louis, Mo., October 10 to 13.

Addresses will be given by men of international reputation. Among them will be Professor S. W. Parr, University of Illinois; O. P. Hood, chief mechanical engineer, U. S. Bureau of Mines; Professor R. T. Haslam, Massachusetts Institute of Technology; H. D. Savage, vice president, Combustion Engineering Corporation; H. W. Brooks, consulting engineer.

Survey of the Gas and Coke Making Properties of American Coals

The Carbonization Committee of the American Gas Association has recommended that that association request the Bureau of Mines to undertake a survey of the gas-and-coke-making properties of American coals. It was pointed out that such a survey was greatly needed to furnish information with reference to the suitability of the different coals of the United States for gas making and the proper temperatures and heat treatment to be used for securing the maximum yield of gas and by-products from these coals. It was also believed that such research would show how better coke could be made from a suitable blending of different coals. It was estimated that the survey would require a period of about five years. Bureau officials have not indicated what action will be taken, but it is anticipated that if such research work should be looked upon favorably, funds therefor will be requested in the next appropriation bill.

Pittsburgh Coal Co. Sues Mine Union for $1,500,000

International, district, and local officers and individuals of the United Mine Workers of America and the National Surety Company have been named defendants in an equity suit filed in Federal Court, Pittsburgh, by the Pittsburgh Terminal Coal Corporation, charging the defendants with cooperation to prevent the plaintiff from moving coal in interstate commerce asked for $1,500,000 damages and sought an injunction to restrain the union men and the surety company from interfering in any way with the operation of its nonunion mines in this district.

The corporation alleged that striking union miners and their sympathizers had attacked and intimidated company employes and had destroyed and damaged company property. It was charged also that striking union miners were resisting efforts of the company to regain possession of company-owned houses, and the court was asked to restrain the surety company from posting bonds in eviction cases. The suit will be argued on September 9.

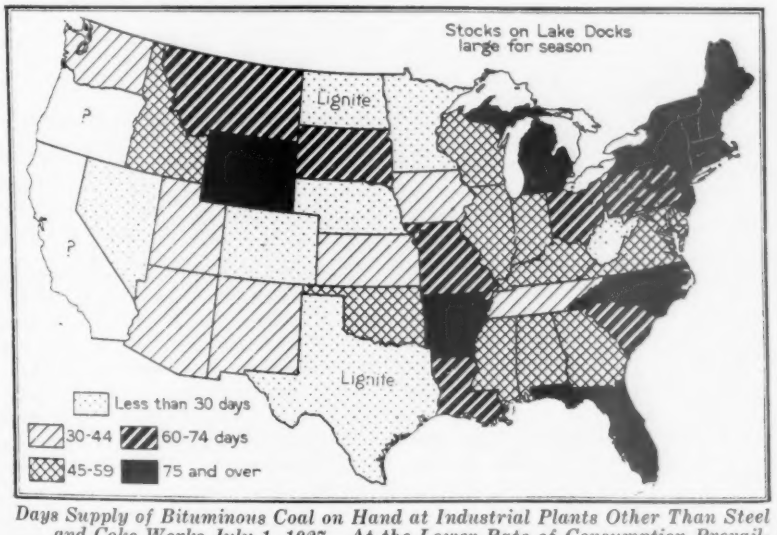
SURVEY OF COMMERCIAL COAL STOCKS

Consumers' stocks of bituminous coal amounted to 62,000,000 tons on July 1, according to a survey just completed by the United States Bureau of Mines, Department of Commerce. In comparison with April 1, the date of the last previous survey, this was a decrease of 13,000,000 tons. In spite of the decrease, the stocks on July 1 were larger than at the corresponding season of any year on record. In comparison with last year they show an increase of 23,000,000 tons.

The consumption of bituminous coal in the second quarter of the year, including exports, averaged 9,305,000 tons a week. Production averaged 8,217,000 tons, leaving a weekly deficit of 1,088,000 tons, which was met partly out of consumers' stock piles and partly out of the very large quantity in transit in railroad cars when the suspension of mining began.

In addition there were 6,840,554 tons of bituminous coal and 1,094,874 tons of anthracite on the docks of Lakes Superior and Michigan.

Stocks of anthracite are fully up to normal for this season of the year.



Days Supply of Bituminous Coal on Hand at Industrial Plants Other Than Steel and Coke Works July 1, 1927. At the Lower Rate of Consumption Prevailing in May and June, the Industrial Plants Reporting Had Enough Coal to Last 64 Days on July 1. The Map Shows How the Days Supply Varied from State to State

West Virginia Safety Meet

The second annual West Virginia Safety Meet will be held in Morgantown on Saturday, September 17, it has been announced by Robert M. Lambie, chief of the West Virginia Department of Mines, following a conference with D. H. Pape, executive secretary and the executive committee of the Monongahela Coal Operator's Association.

In announcing that Morgan own had been selected as the place for the meeting, Chief Lambie stated that several coal fields of the state had waged a vigorous campaign for the meeting but owing to the fact that it was held in Huntington last year, he had decided upon Morgantown in order to touch another distinct coal field. Furthermore, he said, the Monongahela Coal Operators' Association, through Secretary Fape, has been urging Morgantown for more than six months and his decision was influenced largely because of the apparent unanimity in this field for the big meeting.

Last year 121 teams from all coal fields of the state participated in the meet, each team numbering six men. Records at Huntington disclosed that between 18,000 and 20,000 people attended.

Robert Lilly, of Mt. Hope, district mine inspector, will be director of the meet and the judges will include about 125 mine experts from outside of West Virginia.

Perrott Made Superintendent of Pittsburgh Experiment Station

George St. J. Perrott, of North Dakota, has been appointed superintendent of the Pittsburgh Experiment Station of the United States Bureau of Mines. Mr. Perrott succeeds Arno C. Fieldner, recently promoted to the post of chief engineer, Division of Experiment Stations. The Pittsburgh station is the largest of

the eleven experiment stations of the Bureau of Mines, and is one of the notably large research institutions of the world. As superintendent, Mr. Perrott will direct the activities of approximately 200 scientific, technical and other employes in the conduct of various investigations dealing with safety in mining, the elimination of waste in the mining and metallurgical industries, and the technology of fuels, gases, and explosives.

Mr. Perrott, who has been a member of the staff of the Bureau of Mines for the past 10 years, has established a reputation as a research specialist in the technology of explosives and in the physical properties of coal and coke. He is a graduate of the University of North Dakota and took a post graduate course in physical chemistry at Princeton University. In 1917, he joined the staff of the Bureau of Mines. During the World War, he was commissioned as first lieutenant in the Chemical Warfare Service and was in charge of a unit of the Gas Mask Research Section.

Lehigh Coal & Navigation to Mine Under Schuylkill

Hard coal engineers are watching with interest the work to be started soon on mining under water, the Lehigh Coal & Navigation Company having awarded a contract to sink a slope under the Schuylkill River at "High Mines," near Tamaqua, Pa., at a contract price of $250,000. Measures of anthracite of huge tonnage are under the river bed, and years ago some attempt was made at working them, but this was abandoned because of the dangers of floods. The contractor is to erect cement dams at intervals in the new slope to guard against loss of life by water should it break through the river bed because of the workings. The slope is to go down for 400 feet, then have laterals under the river bed to get at the old workings. It is expected it will take a year to complete the work.

Developing Coal Lands North of Denver

Development of a new coal area in Colorado, 14 miles north of Denver's city limits, estimated to produce 10,000,000 tons of coal, is being rapidly carried forward. Actual production of coal will begin in October, and the mining is expected to be in full swing by November. The development is being carried on by the Hartman Exploration and Development Company in a territory that has long been regarded as not having coal underneath it. Previous surveys and drilling to test the ground missed the coal beds by 35 feet. The company has the coal rights on 1,520 acres, which are 3 miles south of Lafayette, Colo. H. C. Beeler, geologist and engineer for the company, estimates that 1,000 acres of the holdings are underlaid with coal varying in thickness from 6 to 7 feet. The company has recently completed sinking a shaft through the coal, which shows a 7-ft. vein at this point, 366 feet beneath the surface.

The company expects to employ between 200 and 300 men when operations get in full swing.

KENTUCKY'S MINERAL RESOURCES

THE Kentucky Geological Survey, Frankfort, has issued a 46-page pamphlet describing the mineral resource of that state. The report was prepared by Willard R. Jillson, State Geologist, and is well illustrated.

Dr. Jillson points out that few areas of similar size in America or the world have been so richly endowed with natural and mineral resource wealth as the State of Kentucky. It will probably be a matter of surprise to many to know that this state stands first in the United States and the world in the production of two very important minerals—fluorspar and native asphalt. In 1926 Kentucky produced 62,495 tons of fluorspar valued at $1,167,129, and 286,850 tons of rock asphalt valued at $2,500,000.

The coal deposits, however, are the largest mineral resource of the state, estimated to be approximately 125,000,000,000 tons. In 1925 Kentucky stood fourth in the United States and America as a producer of coal.

Consumer Owned Coal Mines

According to a special study recently completed by F. G. Tryon and H. O. Rogers, of the Bureau of Mines, 22.1 percent of the total bituminous coal output in 1924 was produced by mines owned by or affiliated with consuming interests. There were 647 mines of this class in operation during the year and the tonnage accounted for by these mines amounted to 107,039,855 net tons. Slightly more than 90 percent of this tonnage was used by the consumer-owner, while the balance, 10,536,993 tons, was disposed of either by local sales or in the open market in competition with commercial coal.

This information is given in the bureau's production report, No. 527. As the principal cost in the reduction of iron ore and the manufacture of steel is that of fuel, says the report, and as an assured supply of uniform quality is of primary importance to the iron and steel industry, it is to be expected that this industry has invested heavily in coal-producing properties. More than 56 percent of the consumer-owned tonnage in 1924 was produced by mines either owned by the steel companies or by the by-product coke plants—the companion industry. The output of mines owned by or affiliated with railroad companies amounted to over 31 percent of the consumer-owned tonnage. The remaining tonnage was accounted for by the public utilities and industrials other than iron and steel companies. Probably the largest producers of coal in this latter group are the brick and tile manufacturing companies.

Tables included in the report show the production of consumer-owned mines in 1924, grouped by business of consumer-owners, and the production and distribution of such mines by states.

Lewis Seeking Review of Injunctions Against Union in West Virginia

The United States Supreme Court has been asked by the Red Jacket Consolidated and 11 other coal companies operating mines in West Virginia to refuse to review 12 cases which John L. Lewis, president of the United Mine Workers of America, wanted to bring to set aside Federal injunctions granted against them.

It was charged that the United Mine Workers had conspired to obtain control of all labor in this country engaged in producing and shipping coal and to prohibit shipment in interstate commerce of nonunion coal produced in West Virginia.

Mining companies insisted that injunctions had brought industrial peace in the coal fields of West Virginia. This peace would last as long as the injunctions remained in effect, they declared, asserting "there have been no armed marches, or Matewan murders or destruction of property or violence or threats of violence against miners who desire to work, since these injunctions have been in effect."

Kentucky Miners Get Wage Boost

A voluntary increase in wages of 20 percent was given 7,500 miners in Muhlenburg and Ohio Counties by the West Kentucky Coal Operators Association, August 16.

The mines are operated on a nonunion basis. Operators, following an unsuccessful attempt by District 23, United Mine Workers of America, to secure a wage agreement on a basis of the Jacksonville meeting, assured their wages would be increased when prices of coal from the district justified the increase. Basis of pay in the field has been on the so-called 1917 scale.

The 20 percent increase granted will raise the wages of men inside to $5.22 a day as a maximum and $5.02 a day minimum, and the outside men to $4.27.

Combustion Engineering Corporation Acquires Sulzer Process for Dry Quenching Coke

George E. Learnard, president of the International Combustion Engineering Corporation, has announced the acquisition from Sulzer Brothers, Winterthur, Switzerland, of the Sulzer System for dry quenching coke, which will be developed in this country by a new subsidiary, the Dry Quenching Equipment Corporation.

The Sulzer System is widely used in Europe for cooling coke without the use of water. Steam is produced for power and plant purposes during the cooling process, thus diverting to useful work the sensible heat of the coke, which is at present lost by wet quenching.

The first unit in America was installed by Sulzer Brothers for the Rochester Gas & Electric Corporation and is operating satisfactorily.

Standard Takes Over German Coal Distillation Patents

An agreement has been made by Walter C. Teagle, president of the Standard Oil Company of New Jersey, and the German dye trust, whereby his company will take over the American right on the Bergius patents for making synthetic gasoline from bituminous coal.

The arrangement with the German dye trust is regarded as a protective move on the part of the New Jersey company in the event of a shortage of crude oil in the future. No early production of synthetic gasoline is believed likely, partly because of the present oversupply of crude petroleum and the fact that the synthetic product can not be produced at a price to compete with gasoline refined from oil.

Dr. Friederich Bergius, of Heidelberg, Germany, described his invention at the International Conference on Bituminous Coal at Carnegie Institute here last November.

The Bergius process has been developed to a point, it is said, where from 50 to 60 percent of the coal can be transformed into oil. One short ton of coal will yield 104 gallons of oil, from which can be obtained 45 gallons of gasoline. It is claimed that nearly all grades of lignite and bituminous coal can be used in the process.

Fuel Research in Great Britain

The Fuel Research Board of Great Britain has just issued its annual report, in which it is stated that while distinct advance is being made in the matter of "low" carbonization it will probably be many years before any appreciable fraction of the 140,000,000 tons of coal burned in the raw state in Great Britain is treated by this method. There are about 200 methods of low-temperature carbonization, and it is emphasized that it is unlikely that any one system will ever be adopted to the exclusion of all others. The report expresses the opinion that the coal stoppage of last year may prove of advantage in the work of research because of its stimulation to interest in the mining industry.

Practical test of low carbonization is to be given by the Gas Light and Coke Co. (Ltd.), which has offered a site for a 100-ton a day plant to be run for three years, the Government paying the original cost of erection. A subsidiary company is to be formed, the gas company to act as managers and bear running costs, and to have the option to purchase the plant at the end of 1930.

ANTHRACITE PRODUCED IN 1926, BY REGIONS

Statistics compiled by H. L. Bennit and F. G. Tryon, of the United States Bureau of Mines

Region	Gross tons	Value *
Lehigh:		
Breaker product	10,251,958	$61,839,454
Washery product	17,461	116,311
Dredge product	52,272	61,743
	10,321,691	$62,017,508
Schuylkill:		
Breaker product	20,833,840	$124,879,696
Washery product	479,618	1,565,929
Dredge product	748,364	753,709
	22,061,822	$127,199,334
Wyoming:		
Breaker product	42,042,204	$280,960,530
Washery product	700,829	2,677,498
Dredge product	16,118	12,946
	42,759,151	$283,650,974
Sullivan County:		
Breaker product	247,918	$1,296,436
Total breaker product	73,375,920†	$468,976,116
Total washery product	1,197,908	4,359,738
Total dredge product	816,754	828,398
Grand total	75,390,582	$474,164,252

* Value given is value at which coal left possession of producing company f. o. b. mines and does not include margin of separately incorporated selling companies.

† Includes culm bank coal put through breaker.

The Bureau of Mines has published statistics showing the tonnage and value of anthracite coal shipped during 1926, by regions and sizes.

Large Illinois Coal Area to Be Reopened

A 7,500-acre coal mining area in Will and Grundy Counties, Illinois, will be in operation this fall by the Northern Illinois Coal Corporation, which will mean the reopening of the old Braidwood-Wilmington field. Seventy-five men are now working near the county line setting up the first stripping unit, and within 60 days a force of 200 miners will be employed there. Four electric shovel units are to be engaged. Estimates of the supplies available are that the field will furnish fuel for 40 years.

The land has been purchased outright by the operating company for $3,500,000, Joseph E. Hitt, president of the corporation, has stated.

Logan Mine to Be Abandoned

After being in operation for almost 100 years, the Logan mine, located in the cliffs of Pomeroy, Ohio, will be abandoned, following an order of court. Fear of a collapse or landslide of the cliff caused Meigs County officials to seek to stop operations at the mine, which is owned by the Durst Coal Company. Common Pleas Judge A. P. Miller granted a temporary restraining order and the officials of the coal company, realizing the danger, agreed to stop work. The mine equipment will be moved to another operation owned by the company up the Ohio River from Pomeroy.

PERSONAL ITEMS

W. W. Inglis, of Scranton, general manager of the Glen Alden Coal Company, was elected chairman of the Anthracite Conciliation Board.

The board accepted the resignation of W. J. Richards, former president of the Philadelphia and Reading Coal and Iron Company, as head of the board, following his retirement from the Reading.

George B. Hadesty, of Pottsville, general manager of the Philadelphia and Reading Coal and Iron Company, succeeds Mr. Richards as the operators' representative from District 9.

H. N. Taylor, president of the U. S. Distributing Corporation, has returned from a sojourn of some weeks in Europe.

Dean E. A. Holbrook, of the Pennsylvania School of Mines, has been appointed head of the College of Engineering at the University of Pittsburgh.

Arthur J. Garrett, of Frackville, Pa., an engineer employed by Madeira, Hill & Company, has been selected to supervise the rehabilitation of several old mines and the opening of four new ones near Kharkoff, Russia, for the Soviet Government. He sailed from New York early in August. Mr. Garrett has been engaged for three years by Stewart, James and Cook, engineers, who have the contract with the Soviet Government, and he will be accompanied to Russia by Charles D. Stewart, of that firm.

James Pierce, of the Buck Run Coal Company, who has been at Kharkoff for some months on leave of absence, will remain there until the arrival of Mr. Garrett, returning to America some time in September. He is expected to go back to Russia later.

James B. Pauley, of Chicago, formerly president of the J. K. Dering Coal Company, has recently become associated with the Miami Coal Company in the capacity of director and chairman of the board.

Arno C. Fieldner, chief engineer in charge of experiment stations of the Bureau of Mines, is making an inspection tour of all the experiment stations of the bureau. He will return to Washington early in October.

Thomas Moses, general manager of the United States Fuel Company at Danville, Ill., has been elected president of the H. C. Frick Coke Company to succeed the late W. H. Clingerman; Thomas Dawson, chief engineer of the company was elected vice president.

Judson C. Welliver has resigned as director of Public Relations of the American Petroleum Institute to become editor of the *Pittsburgh Post-Gazette*.

The following is a list of special circulars issued since January 1 by the Minerals Section of the Department of Commerce. Each one is designated by a number, and copies of any of them may be obtained from the Minerals Section, Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C., or through THE MINING CONGRESS JOURNAL.

Africa, British South: No. 616, Coal Trade in 1926.

Argentina: No. 557, Imports 1926 into Buenos Aires.

Australia: No. 541, Coal Trade in 1926.

Brazil: No. 551, Coal Import Trade of Rio de Janeiro in 1926; No. 619, Coal Import Trade in Bahia.

China: No. 565, Coal Trade in China.

Canada: No. 525, Coke Trade in 1926; No. 530, Coal Trade in 1926; No. 594, Coal Mining in Nova Scotia in 1926; No. 613, Encouraging Coke Production.

Egypt: No. 482, Egyptian Coal Trade.

France: No. 476, Coal Trade of Nice; No. 501, Coal Trade of Havre; No. 547, Coal Trade of Deippe; No. 549, Coal Trade of Rouen; No. 558, Coal Trade of Bordeaux; No. 575, The French Coal Problem; No. 612, Coal Stocks at Various Ports.

Great Britain: No. 477, Amalgamation of British Companies; No. 474, Trade of Newcastle-on-Tyne; No. 502, The Situation in the Coal Industry; No. 522, Some British Coal Contracts; No. 524, Price Stabilization Measures; No. 566, Taxation in Newcastle Coal Mining District; No. 602, Coal Contracts in Europe; No. 604, Efforts on Continent to Gain Freedom from British Supplies; No. 614, Coal—Prices and Costs in Great Britain.

Germany: No. 542, Coal Trade in 1926; No. 548, Developments in Brown Coal Fields of Central Germany; No. 552, Coal Utilization Processes.

Italy: No. 493, Imports of Coal Into Genoa and Coal Trade Customs of that Port; No. 496, Italy's Coal Reserves—Better Use of National Fuel; No. 507, Coal Market of Venice and Venezia.

Malta: No. 527, Coal Trade of Malta.

Malaya, British: No. 595, Coal Imports Into British Malaya.

Netherlands: No. 600, Coal Mining in 1926.

Newfoundland: No. 567, Coal Trade of Newfoundland.

Nova Scotia: No. 594, Mining in 1926.

Portugal: No. 473, Coal Market of Oporto.

Spain: No. 607, Coal in 1926.

United States: No. 537, Coke, Exports, 1925-26, by Months and by Customs Districts; No. 553, Anthracite, Exports from, in 1924, 1925, 1926; No. 593, Imports of Coal and Coke Into United States During First Quarters 1926 and 1927.

Bunker Coal and Oil Supplied to Foreign Vessels: No. 528, years 1925 and 1926; No. 533, January, 1927; No. 560, February, 1927; No. 597, March, 1927; No. 609, April, 1927; No. 623, May, 1927.

Ocean Freights: No. 490, Tying-up Outbound Coal Shipments With Inbound Raw Products; No. 526, A Comparison of Ocean Freights, Cardiff, Rotterdam, and Hampton Roads.

Oil from Coal: No. 499, German "Oil from Coal" Plant Under Construction; No. 523, Distillation of Chilean Coal; No. 552, German Coal Utilization Processes; No. 611, The Liquefaction of Coal in Germany.

Oil vs. Coal: No. 605, For Bunkering Ships.

Prices: No. 539, Bunker Coal, Diesel and Fuel Oil Prices at Various World Ports.

Pitch: No. 485, Exports of Pitch—Great Britain; No. 505, Coal Tar Pitch in International Trade; No. 554, Review of Tar and Pitch in 1926 in Great Britain; No. 552, Coal Utilization Processes; No. 564, Production of Coal Tar Pitch in Leading Countries.

Foreign Trade Notes (Each bulletin covers several countries).—No. 497, Amalgamations in Great Britain; No. 519, Low Temperature Carbonization in England; No. 540, A Zuyderhoudt Low Temperature Process, Lignite Tests in Australia, British Export Credit Scheme; No. 546, An All Canadian and British Fuel Supply; No. 608, New Coke Plants in Canada, Miners' Earnings in Germany, Austrian Process for Drying Lignite.

Briquetting: Special Circular No. 577, Production in the Leading Countries.

Coal Operators in Colorado and New Mexico Against Natural Gas Line

The proposal of the Colorado Interstate Gas Co. to pipe natural gas from the Amarillo field in Texas to Denver and intervening cities is awaiting the action of the Denver City Council on rates for domestic consumers. Plans have been perfected for the beginning of construction work.

Opposition to the piping of gas from Texas has arisen among the coal operators in Colorado and New Mexico, the railroad companies and others on the ground that it will be injurious to the coal industry, throw miners out of employment, reduce available tonnage for the railroads and cause a considerable liquidation in the state's pay roll. Numerous figures have been submitted to prove their contention. One statement put the decrease in coal production handled by the railroads at 1,362,000 tons a year. Figures also include losses to the state in royalties on coal mined on state land, reduction in taxes,

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Pulverized Coal Used in Electric Power Plant at Mine Mouth

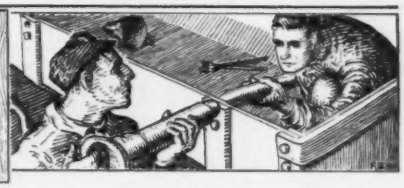
The Kentucky Electric Power Corporation, subsidiary of the Norton Coal Mining Company, and Monroe Warrior Coal Company, which is completing a 90,000-h. p. steam generating plant at the mouth of the Nortonville, Ky., coal plant, has contracted with the Kentucky Utilities Company of Louisville to hook up the new station with the K. U. lines, and will sell 4,000 h. p. of the production to this company for distribution over its network of western Kentucky transmission lines to many towns, mines, etc., of the territory. The balance of the power generated at the plant will be used by the Norton Coal Company and its affiliated mines, all of which are being completely electrified.

New Tipple in Mingo County

The new Crystal Block Coal Company tipple in Mingo County, W. Va., will be ready for use about September 20, replacing the old tipple destroyed by fire about three months ago, together with 200 yards of conveyor line, at a loss of $55,000. The new tipple is of steel construction.

Final statistics compiled by the Bureau of Mines of by-product coke in 1926 are now available. The tables published by the bureau show the by-product coke produced, used by producers and sold; the number and production of plants connected with iron furnaces and all other plants, 1913 to 1926; and the by-products obtained from coke-oven operations in 1926.

WITH THE MANUFACTURERS



A Portable Mine Substation

A portable mine substation which can be moved to a new location in approximately eight hours has been installed by the Union Colliery Company in its mine at Dowel, Ill. Operation of this mine necessitates the frequent moving of the converter substation in order to maintain the desired voltage of direct-current supply at the mining face. It is estimated that it will be necessary to move the substation every three to six months, and it is, of course, undesirable to interrupt the production of coal by the moving.

To meet the situation a unique substation has been installed in the mine, equipped with a General Electric, semi-automatic, 200-kilowatt synchronous converter with transformer and control equipment, all so arranged that the entire substation can be moved to a new location within approximately eight hours.

The transformer, switchboard and control panels are all mounted on trucks, which are of the same gauge as the mine tracks. The converter base has structural steel projections to which trucks are detached from the converter base after the set has been moved, and the unit is then bolted and grouted to the substation floor.

In designing the substation the factor of headroom was found to be important, it being necessary to keep within a limit of 4 ft. 6 in. Ventilation is also an important factor, and the substation rooms are so arranged that that they will be ventilated always by intake air.

Diagonal Deck Sand and Slime Table

The Deister Concentrator Company, Fort Wayne, Ind., manufacturers of ore concentrating and coal-washing tables, are marketing a new sand and slime table, known as No. 6 Deister-Overstrom Diagonal Deck.

The Diagonal Deck spreads the feed out over its surface in a broad, thin zone, effecting perfect stratification. Thinner riffles are used, with almost double the number of riffles on other types of table. The proper placing of the riffle terminals on the concentrate end of the deck maintains the "mineral line" and is very effective in producing high-grade concentrate, high extraction of values, small middlings, and large capacity.

A descriptive folder will be sent to anyone on request.

Large Capacity Dorr Thickener

An example of engineering progress and success in building large equipment to meet the increasing tonnage requirements of modern industry has come to light in the purchase recently of the largest Dorr Thickener ever built. This Dorr Thickener, which is of the traction type, is 325 ft. in diameter, and some conception of its size may be obtained when it is realized that it will provide almost 2 acres of settling area.

This unit will be used at the copper flotation plant of the Miami Copper Company, Miami, Ariz., for dewatering 16,000 tons of mill tailings and recovering for reuse in the plant about 11,500,000 gallons of water per day. This Dorr Thickener has more than twice the capacity of any thickener built before. With the exception of certain improvements, the design closely follows that of the 200-ft. units at Inspiration Copper Company, which have been operating several years in this district.

A New Speed Reducer

Link-Belt Company, Chicago, have recently put on the market the "Link-Belt Sykes Herringbone Speed Reducer," which is illustrated and described in their Book No. 715.

This speed reducer can be economically applied to all classes of service, no matter how light or heavy it may be. Distinct advantages are quietness of operation, high efficiency and ability to withstand shocks.

Three standard units have been developed to cover a wide range of ratios and capacities. The single reduction unit designated as type "S" covers ratios up to 10 to 1. Types "D" and "DV" are double reduction units. Type "D" is designed for heavy duty and ratios are from 10 to 1 up to 80 to 1. Type "DV" is a light duty reducer. Ratios range from 10 to 1 up to 130 to 1.

Link-Belt Sykes Herringbone Gears are the backbone of this speed reducer. The teeth run continuously across the face of the gear, giving a good bearing service with the several teeth engaged. The pinions are of heat-treated alloy steel cut integral with the shaft.

The unit has a minimum number of parts. Oversize Timken bearings are used. Gears rotate within a large oil reservoir and bearings are splash lubricated. This provides ample lubrication. Special oil baffles at shaft projections keep dust out and oil in. The housing is free from troublesome oil grooves and oil wipers.

Rigid construction insures proper alignment of parts and the base plate furnished when required maintains alignment of the reducer and its motor.

Copies of Book No. 715 may be obtained from the company's offices, 910 South Michigan Avenue, Chicago.

Electrically Heated Bath Water Saves This Mine Money

The Valier Coal Company, of Valier, Ill., recently adopted electric heat for heating bath water for such of its employes as are at work on holidays or other days when most of the force is idle. This method resulted in a substantial saving.

The steam-heating system, still used for work days, when it provides for the needs of about 600 men, requires about 5 tons of coal per day and the services of three firemen for its operation. Because of the necessity for the employment of maintenance and construction men, this system had to be kept in readiness on idle days and holidays as well as on working days, and at no reduction in cost over the expense of operation on working days.

The initial electric heating installation now meets all the requirements for idle days and shut-down periods at a substantial decrease in operating cost. It is considered to be sufficient for 50 or more men, but is normally used by about 15 only.

The water is heated in a 235-gallon, heat-insulated, hot-water tank by six 5,000-watt, 220-volt, helicoil sheath-wire immersion heating units furnished by the General Electric Company.

It has been found that the cost of steam operation on either work days or idle periods is $34.25 per day, while that of electric heat used on idle days is only 7.64, which means a saving of $26.61. This based on raising the temperature on 25 gallons of water for each of 15 men at a temperature of 60 to 105 degrees F., at a rate of 1.3 cents per kilowatt-hour for current by electrical operation. The expense of steam includes the cost of 5 tons of coal and the wages of three firemen.

Largest Self-Aligning Roller Bearings in the World Running Successfully for Over Three Years

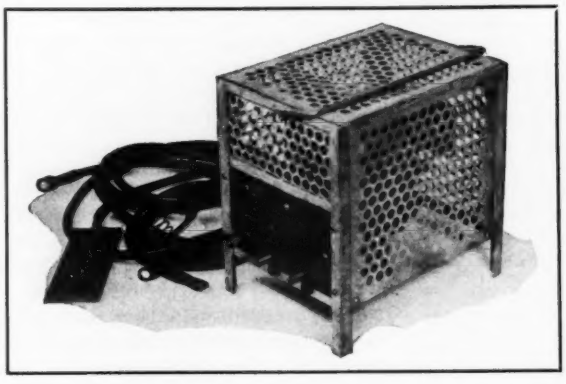
Two huge S K F Spherical Bearings, of the type shown in the accompanying photograph, the largest of their kind in actual service the world over, have been successfully operating for a period of over three years in a "cylpeb" cement mill at the plant of the Dexter Portland Cement Company, Nazareth, Pa. These bearings, almost 3 ft. in diameter, are carrying the load of a 5½ ft. by 26 ft. tube mill used in pulverizing. The mill is driven by a 250 h. p. motor at a speed of 26 r. p. m. The load is 50 tons, or 25 tons per bearing.

During the three-year period these bearings have been on the job continuously, and the only attention required has been replenishing of lubricant several times a year. In addition to carrying heavy thrust and radial loads, an important feature of these bearings has been their self-aligning characteristics. Any inaccuracies in setting up and settling of foundation is compensated for within the bearings without the need of any external aligning devices or the setting up of internal strains or stresses.

S K F Spherical Bearings in principle differ from the conventional type of roller bearing in that they are self-contained and non-adjustable units. These bearings are made of high carbon chrome steel and uniformly hardened throughout. The rollers are of a barrel shape, and each of the two rows of rollers is permitted to operate independently of the other. The rollers and races of S K F Spherical Bearings are made from charcoal steel, a produce of the S K F iron ore mines and steel mills in Sweden. Each roller is drop-forged and individually turned between centers to the highest precision.

In frictional characteristics S K F Spherical Bearings run a close second to ball bearings. They are made as well as S K F Ball Bearings from the standpoint of materials, workmanmanship and finish.

The spherical bearing applications include loads of over 500,000 pounds per bearing. They are built in the largest sizes and today are being used on giant steel mill motors, rolling mills, rock crushers, coal crushers, crushing rolls in flour mills, dredge pumps, and on over 9,000 standard railway cars and auxiliary equipment throughout the world.



"Shuntweld" Arc Control Improves Steel Metallic Arc Welding

Any mine property which uses any type of resistance welder of 200 ampere or more capacity will be interested in the Shuntweld arc control, a new device just patented by the Ohio Brass Company, Mansfield, Ohio. This new device, for use where electrode polarity is negative, makes a good substitute for the heavy and expensive M-C type of welder.

It is desirable in shop welding work for more reasons than one. It reduces striking and maximum operating arc voltages; eliminates spattering steel globules, a condition which results in less electrode consumption; cuts out brittle and oxidized metal and results in better mechanical and electrical characteristics of deposited metal; results in less difficulty with electrode "freezing" to the work; and finally it is usable with any 250 volt, 200 ampere or larger resistance type welder.

This device consists of a magnetic switch, automatically controlled, with small shunt resistance mounted in a small frame, forming an individual unit which, when connected to the standard O-B 250 volt welder, will produce the equivalent of the old shunt welder or a motor generator type welder.

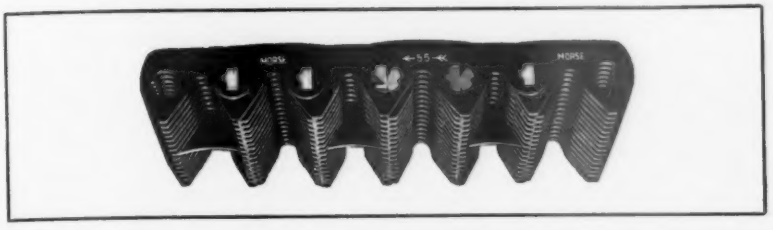
Two maximum values of arc voltage or arc length, high and low, are indicated on the panel board and manipulated by a small switch. The maximum arc length provided for is about ⅜ in., since anything higher than that results in a very brittle, porous weld and high electrical resistance.

Size of welder, 9 in.-12 in.-12 in. Instruction sheet and simplified electrical diagram of connections which go with it make it easy for anyone to make connections quickly and without trouble. Necessary cables are furnished to make quick connections to O-B Standard 250 volt, 200 ampere welder, and only one or two minor changes are necessary to make it possible to hook it up to any other welder. It's a valuable adjunct for the operator who wants to prevent high arc voltage in the ordinary welding machine.

Establishment of Dorr Prize in Metallurgy

Mr. John Van Nostrand Dorr, president of the Dorr Company, engineers, has established at the South Dakota School of Mines, a prize of $100 in cash, to be awarded each year at commencement to that student in metallurgy who by work accomplished, character and general fitness, gives promise of high accomplishment in the metallurgical field.

In the development of the mining and metallurgical interests of the Black Hills of South Dakota, Mr. Dorr was formerly very active. It was in this district that the Dorr Classifier and Dorr Thickener were first introduced, the use of which has subsequently become standard practice in a great many chemical and industrial operations, in addition to the metallurgical ones for which they were originally developed.



Morse Company Puts Out New Chain

The Morse Chain Company, Ithaca, N. Y., long noted as the manufacturer of the original rocker-joint chain and the largest manufacturers of silent chain drives in the world, has announced an improved chain. The improvements are principally due to changes in the design of the rocker joint.

The new design, 55 type chain, will run on all sprockets, the new link being the same length and height as the old.

The new joint, shown in the illustration, operates on the same principle as the original Morse Rocker Joint. The seat pin, at the left, has been enlarged to give greater bearing surface and also to make it a stronger transverse member to hold the chain together.

The rocker pin, at the right, has been changed in contour, thereby giving a better surface of contact with the links.

The combined joint members give a more nearly round hole with reduced clearance, holding the links more securely on the pins. A better balanced joint, heavier than the old, produces a smoother running chain. It is a more rugged chain—the joint pins are about 8 percent heavier and the complete chain weighs twice the pitch per inch foot. The breaking strength is increased about 50 percent.

The improved, better balanced joint, with larger bearing surfaces and pins more securely held in the links permits increased tension without shortening the life of the drive.

The Morse Chain Company also announces at this time that it has recently installed the most modern automatic electric furnaces to insure the more uniform heat treating of the parts entering into the chain.

Atomic Hydrogen Welding Is Now Made Practicable

Atomic hydrogen welding—the process by means of which hitherto unweldable metals can be melted and fused without the slightest trace of oxidation, and welding can be performed in some cases on metals as thin as the paper on which this is printed—is now made practicable by the use of equipment placed on the market by the General Electric Company. This process, making possible the welding of many special alloys and the production of ductile welds in iron and steel, is the result of research conducted by Dr. Irving Langmuir of the General Electric research laboratory.

In brief, this method utilizes the passage of a stream of hydrogen through the arc between two electrodes. The heat of the arc breaks up the hydrogen molecules into atoms. These combine again a short distance beyond the arc into molecules of the gas, and in so doing liberate an enormous amount of heat, so that more effective welding temperatures can be obtained than with the usual welding methods.

The welding outfit consists of the following: (1) A single-phase transformer for converting the voltage of a 60-cycle source of power to one suitable for the welding equipment; (2) a specially designed, variable reactor to provide the proper welding current and voltage for different classes of work; and (3) the welding torch by means of which the actual work of welding is performed.

The new equipment is so far being marketed for operation from 60-cycle, single-phase circuits only, and is recommended for use on ordinary metals of less than ¼ in. in thickness, or on hitherto unweldable metals of greater thickness. Metals having a thickness of but 10 mils can easily be welded and little doubt is expressed that, in some cases, work as thin as 2 mils (about the thickness of ordinary writing paper) can be welded.

Because of the absence of oxides and nitrides from the weld made by this process, it is particularly adaptable to the welding of special alloys so far not weldable by other methods, and also makes a strong, smooth and ductile weld on ordinary iron and steel work. Inasmuch as pure chromium, nickel, copper, aluminum, silver, and other metals and their alloys—not to mention iron and the more common metals—can be melted without oxidation, it is expected that new possibilities will be opened in such welding, although the field of application has been but partly studied.

Electricity in the Coal Mine

"Electricity in the Coal Mine" is the title of circular 1782 recently prepared by the Westinghouse Electric and Manufacturing Company. Such important problems as cutting, loading, conveying, haulage, hoisting, ventilation, tipple and breaker drive, pumping, and power distribution are discussed, showing the special features necessary to make electrical apparatus safe for mine work, also the advantages gained by the use of such apparatus. This circular may be obtained at any Westinghouse district office, or directly from the Advertising Department at East Pittsburgh.

New Sullivan Bulletins

The following bulletins have recently been published by the Sullivan Machinery Company, Chicago, Ill. Copies will be furnished upon request:

Portable Air Compressors.— Bulletin 83-F, 32 pages. Describes Sullivan Portable Air Compressors, gasoline engine driven and electric motor driven types. They are in popular use by contractors, mines, quarries, municipal departments, and public utilities. Gasoline types are operated by Buda engines direct connected and are built in four sizes, namely 110-ft., 160-ft., 220-ft. and 310-ft. capacities. The first two are two cylinder vertical units, the last two are four cylinder 90 degree units of the balanced V compressor type. Electric units are also built in 103 and 206-ft. compressor sizes.

Sullivan Portable Turbinair Hoists.— Bulletin 76-F, third edition. Describes the Sullivan air turbine driven portable hoists, both single and double drum for mining, contracting, and quarrying service; also widely used as car pullers, for hoisting materials in industrial service of various kinds. The double drum units are favored for slushing or dragline scraper work in mines and open cuts. Sixteen pages, with numerous illustrations of the machines at work.

Sullivan Stoping Drills.— Bulletin 81-G, 20 pages. Describes two types of Sullivan compressed air stopers for upper hole drilling in mines and on contract work such as shaft raising. The "DU-48" heavy duty, self-rotating hammer drills have been improved in important particulars, providing additional drilling speed and ease of handling. They are equipped with automatic rifle bar rotation, with needle valve control of the flow of water, and one hand control of the admission of air to the drill cylinder, and of the speed or rate of advance of the drill.

"DT-44" hand rotated light stopers are available in either water or dry types, and have recently been improved by incorporating the one-hand control of the feed and air supply.

PUBLIC LAND OWNERSHIP

(*Continued from page* 705)

population, and its existence as a check should be maintained.

It should not remain forever under the Government as a perpetual landlord, but should be released as required by economic necessity. Perhaps greater justice might be done the western states through direct compensatory appropriation by Congress for policing and road maintenance and other expenditures occasioned by existence of domains within their borders which they do not own and which are untaxable.

MEETING OF NEW MEXICO CHAPTER

(*Continued from page* 733)

A short talk was made by Mr. H. H. Fields, ore purchasing agent of the El Paso Smelting Works, entitled "Silver Producers Association."

At the conclusion of the meeting members drove by automobile from Santa Rita to Silver City and en route visited the properties of the Hanover Bessemer Iron & Copper Company at Fierro, The Empire Zinc Company and Black Hawk Consolidated Mines Company at Hanover, and the Hayward-Richards Leasing Company at Vanadium. In Silver City the members were guests of the Grant County Chamber of Commerce at lunch, where the chapter was royally welcomed and the importance of the mining industry in the economic life of the state stressed in the welcoming address. Following the lunch the members inspected the manganese deposits of Boston Hill near Silver City, and the properties of the Phelps Dodge Corporation at Tyrone.

This was the best and most representative meeting of mining men ever held in the State of New Mexico, both from the standpoint of the number attending, as well as the enthusiasm displayed. The success of the meeting was largely aided and abetted by the enthusiastic cooperation of the ladies' committee. It is needless to add that the feminine touch given by the members of this committee made the meeting much more enjoyable than it could have been otherwise.

MANGANESE PRODUCERS ORGANIZE

(*Continued from page* 734)

"9. Evidence to the effect that the cost of producing and delivering ore to the furnace is greater from domestic properties than from foreign properties.

"Manganese is essential in the life of American industry; it is essential in the manufacture of war material; there is no substitute. The development of the manganese resources of America should receive the encouragement of the Government and the country at large. Manganese or the manganese tariff should be nonpartisan. It should receive the support of every department of the Government, every organization, and every individual who has the good of America at heart. We should not allow ourselves to be dependent upon foreign countries when we have undeveloped reserves of undetermined extent in our own country. As long as developments will tend to increase the known reserve of this all-important material just so long should research and development continue."

Concerning the importance of methods of beneficiation, L. B. Miller of Cleveland, Ohio, said that "not only in Arkansas but in many other states in the United States are enormous bodies of ore which are not high grade in their present condition, but by methods of beneficiation which are now in process of being tested out, pyrometallurgical, magnetic, leaching—by putting manganese and pig iron in a blast furnace—many of these ores can be transformed and will be transformed and will make ferro manganese which is essential for the industries of this country."

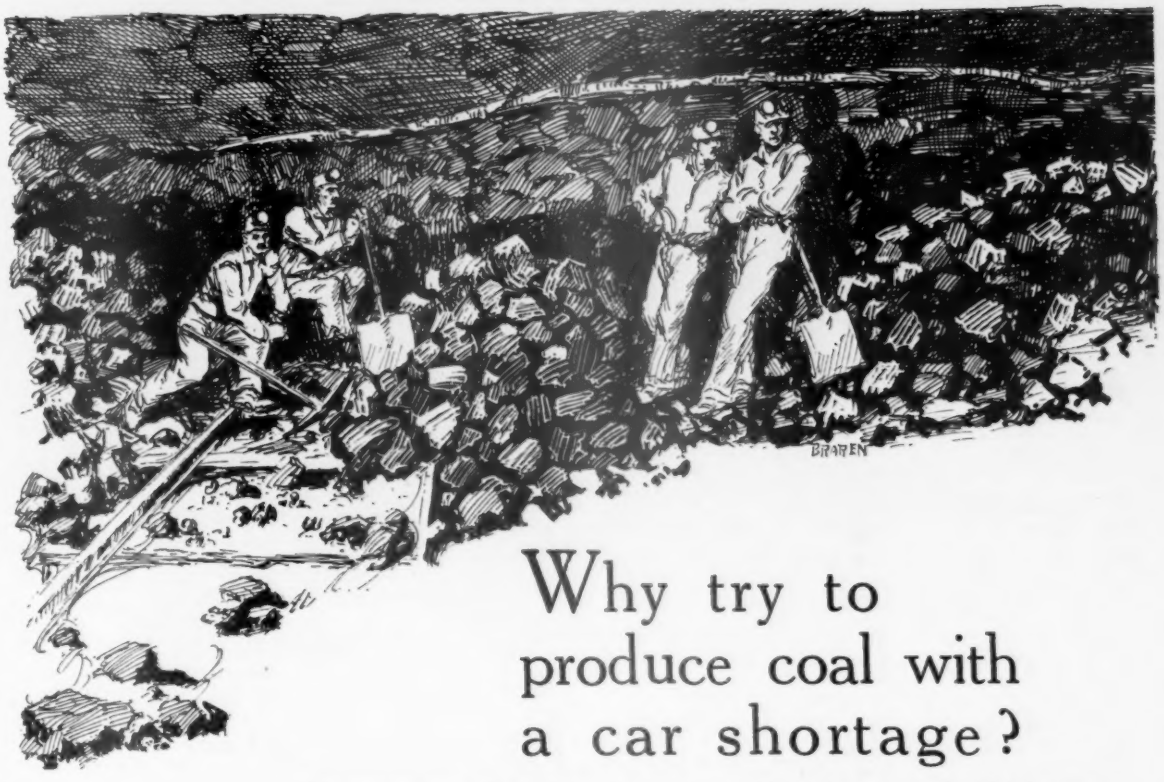
He predicted that more than 50,000,000 tons of manganese ore could be recovered from the clays of the Batesville District of Arkansas through beneficiation processes now being improved and tested.

Other speakers referred to new developments and discoveries that have been made in recent years and contended that during the few years that the tariff has been in effect the manganese producers have not had a proper opportunity to show the results that are admitted by those who oppose the tariff. They said that if given an opportunity to complete the development of their ore reserves and to put into operation methods that have been developed for treating these ores, it will not be long before the manganese industry of this country will be on its feet. Some of the speakers told of contracts that have been made for the delivery of large tonnages of ore during the next five years aggregating approximately 200,000 tons per year, a large portion of which will be produced in the State of Montana.

State geologists of Arkansas, Virginia and Tennessee addressed the meeting and outlined the encouraging progress that has been made in their states during the last five years. Representatives of the Bureau of Mines and Geological Survey invited the cooperation of the association and of the manganese producers in the assembling of data on the known and newly developed manganese deposits, their plans for operation of their mines and their capacity for production.

The statements of the manganese producers present at the meeting indicated that fairly large investments have been and are being made for the development of manganese deposits and that many of these are just now at the production stage with the prospect for steady operation and increased production year by year from now on. They stated that the evidence concerning these operations will be presented to the Tariff Commission for consideration in connection with the Commission's investigation of manganese.

An old ferry on the Potomac © *Harold Gray*



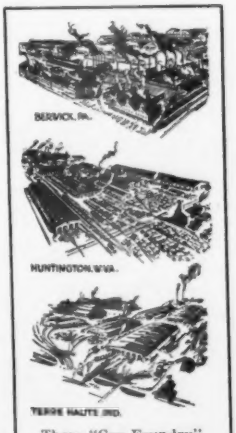
Why try to produce coal with a car shortage?

No matter how efficient your locomotives, mining machines, loaders, drills and explosives may be, you can't get the coal out without enough cars and the best cars it is possible to make.

If you have been making your own cars, it won't pay you to wait for your shop to turn out the cars you need. You can secure them much more quickly, probably at no greater initial cost and far more serviceable from "Car Foundry."

"Car Foundry's" three immense up-to-date plants, one of which is sure to be located at a short distance from your mine, can supply you with the cars best suited to your haulage conditions, at a minimum figure and in an amazingly short space of time. "Car Foundry" Engineers will be glad to look over your haulage problem, design a new car for you or duplicate the car you are now using. Whatever car will do most to increase your tonnage and cut your cost-per-ton, you can get from "Car Foundry."

Buy "Car Foundry" cars.



These "Car Foundry" Plants, each in the heart of a great mining region, enable us to render a national service with "localized" advantages—no matter where your mine is located.

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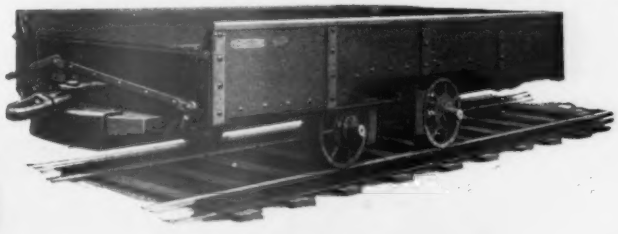

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Irvington Smelting & Refining Works, Irvington, N. J.

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AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.

AIR HOSE COUPLINGS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

AIR LIFT PUMPING
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

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John A. Roebling's Sons Co., Trenton, N. J.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ARMORGRIDS
Hendrick Mfg. Co., Carbondale, Pa.

AUTOMATIC CAR CAGES
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Roberts & Schaefer Co., Chicago, Ill.

AUTOMATIC CAR DUMPERS
Roberts & Schaefer Co., Chicago, Ill.

AUTOMATIC (Mine Doors, Trucks and Electric Switches)
American Mine Door Co., Canton, Ohio.

AUTOMATIC SWITCH THROWERS
American Mine Door Co., Canton, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

AUTOMOBILE CABLES
John A. Roebling's Sons Co., Trenton, N. J.

BALLAST UNLOADER ROPES
John A. Roebling's Sons Co., Trenton, N. J.

BARS, STEEL
Carnegie Steel Co., Pittsburgh, Pa.

BATTERIES, DRY (for Bells, Buzzers, Signals, Blasting)
National Carbon Co., Inc., 30 East 42nd St., New York City.

BATTERIES (Storage, Gas Welding, Cutting, Dissolved Acetylene)
Prest-O-Lite Co., 30 East 42d St., New York City.

BELL CORD
John A. Roebling's Sons Co., Trenton, N. J.

BELTING (Conveyor, Elevator, Transmission)
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

BELTING, SILENT CHAIN
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BINS (Coke and Coal)
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

BITS Carbon (Diamonds) for Core Drill
R. S. Patrick, Sellwood Building, Duluth, Minn.

BITS, Diamond Drilling
R. S. Patrick, Sellwood Building, Duluth, Minn.

BIT SHARPENERS
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.

BLACK DIAMONDS
R. S. Patrick, Sellwood Building, Duluth, Minn.

BLASTING POWDER
Atlas Powder Co., Wilmington, Del.
E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del.
Hercules Powder Co., 934 King St., Wilmington, Del.

BLASTING SUPPLIES
Atlas Powder Co., Wilmington, Del.
E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del.
Hercules Powder Co., 934 King St., Wilmington, Del.

BLASTING UNITS (Dry Battery)
National Carbon Co., Inc., 30 East 42nd St., New York City.

BLOWERS, CENTRIFUGAL
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Robinson Ventilating Co., Zelienople, Pa.

BLOWERS (Tubing)
Robinson Ventilating Co., Zelienople, Pa.

BLOWERS (Turbine)
Robinson Ventilating Co., Zelienople, Pa.

BLOWPIPES, Brazing, Carbon Burning, Cutting, Lead Burning, Welding, Welding and Cutting
Oxweld Acetylene Co., 30 E. 42d St., New York City.

BLUE CENTER STEEL WIRE ROPE
John A. Roebling's Sons Co., Trenton, N. J.

BOND TERMINALS
American Mine Door Co., Canton, Ohio.

BORTZ
R. S. Patrick, Sellwood Building, Duluth, Minn.

BREAKER MACHINERY
American Rheolaveur Corporation, Wilkes-barre, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.

BREAKERS (Construction and Machinery)
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

BREAST MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

BRIQUETTING MACHINERY
Vulcan Iron Works, Wilkes-Barre, Pa.

BRUSHES (Carbon, Graphite and Metal Graphite for Electric Motors, Generators and Converters)
National Carbon Co., Inc., Cleveland, Ohio and San Francisco, Calif.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

BUCKETS (Elevator)
Hendrick Mfg. Co., Carbondale, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CABLE GREASE
Keystone Lubricating Co., Philadelphia, Pa.

CABLES
American Steel & Wire Co., Chicago and New York.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Roebling's Sons Co., John A., Trenton, N. J.

CABLES (Connectors and Guides)
American Mine Door Co., Canton, Ohio.
Leschen & Sons Rope Co., A., St. Louis, Mo.

CABLES, INSULATED
John A. Roebling's Sons Co., Trenton, N. J.

CABLES, SUSPENSION BRIDGE
John A. Roebling's Sons Co., Trenton, N. J.

CABLEWAYS
American Steel & Wire Co., Chicago, Ill., and New York.
S. Flory Mfg. Co., Bangor, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

CAGE DUMPERS, ROTARY
Roberts & Schaefer Co., Chicago, Ill.

CAGES (Safety Appliances)
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

CAGE STOPS & LOCKS
Mining Safety Device Co., Bowerston, Ohio.
Roberts & Schaefer Co., Chicago, Ill.

CAGERS, AUTOMATIC
Mining Safety Device Co., Bowerston, Ohio.

CAGERS, AUTOMATIC & MANUAL
Roberts & Schaefer Co., Chicago, Ill.

CAGES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.

CAGES (Self-dumping)
Roberts & Schaefer Co., Chicago, Ill.

CALCINERS
Vulcan Iron Works, Wilkes-Barre, Pa.

CALCIUM CARBIDE
Union Carbide Sales Co., 30 East 42nd St., New York City.

CARBON AND BORTZ
R. S. Patrick, Sellwood Building, Duluth, Minn.

CARBON FOR DIAMOND DRILLING
R. S. Patrick, Sellwood Building, Duluth, Minn.

CARBON BURNING APPARATUS
Oxweld Acetylene Co., 30 E. 42d St., New York City.

CARBON ELECTRODES (for Electric Furnaces and Electrolytic Work)
National Carbon Co., Inc., Electrode Sales Division, 30 East 42nd St., New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CARBONS (for Arc Lamps, Blue Printing, Photographic)
National Carbon Co., Inc., Cleveland, Ohio and San Francisco.

CARBON RODS AND PASTE FOR WELDING
Oxweld Acetylene Co., 30 E. 42d St., New York City.
National Carbon Co., Inc., Cleveland, Ohio, and San Francisco, Calif.

CARBON SPECIALTIES (Circuit Breaker Contacts, Packing Rings, Filter Plates, Tubes, etc.)
National Carbon Co., Inc., Cleveland, Ohio, and San Francisco, Calif.

CAR DUMPERS, GRAVITY & POWER
Roberts & Schaefer Co., Chicago, Ill.

CAR DUMPERS (Rotary)
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

CAR FEEDERS
Roberts & Schaefer Co., Chicago, Ill.

CAR HAULS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

CAR PULLERS
S. Flory Mfg. Co., Bangor, Pa.

CAR RETARDERS
Roberts & Schaefer Co., Chicago, Ill.

CAR STOPS, AUTOMATIC & MANUAL
Roberts & Schaefer Co., Chicago, Ill.

CAR WIRE & CABLES
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

CASTINGS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CASTINGS, GRAY IRON
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

CASTINGS, OPEN HEARTH STEEL
Vulcan Iron Works, Wilkes-Barre, Pa.

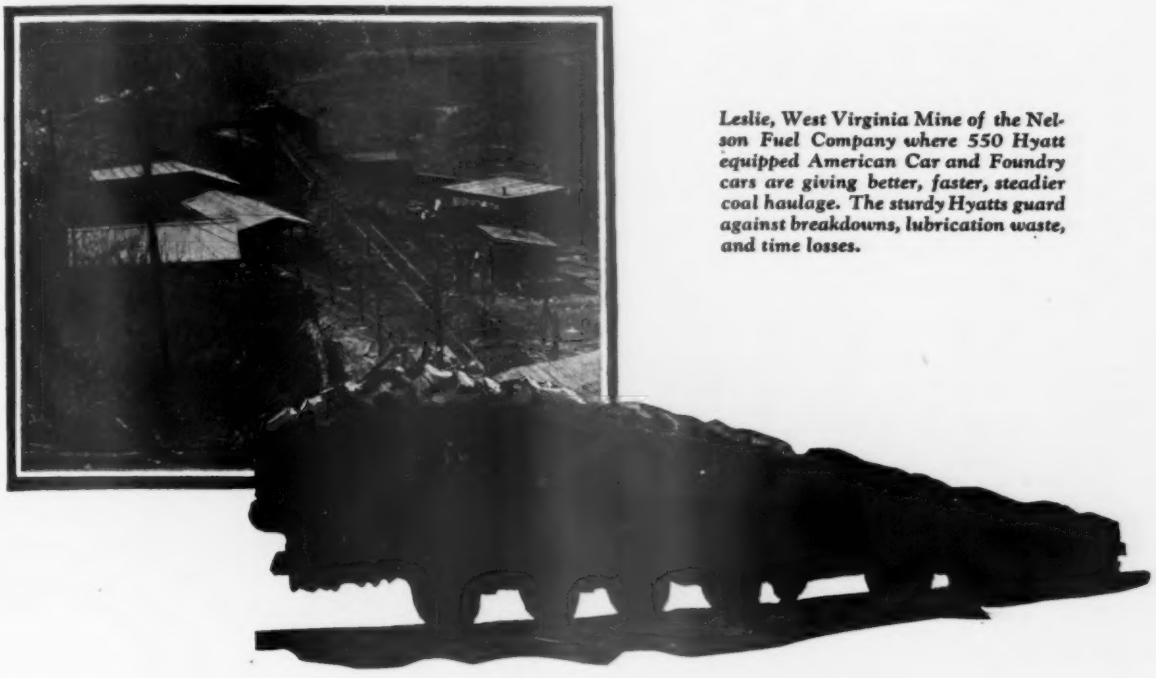
CHAINS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHAINS, AUTOMOBILE ENGINE
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHAINS, COAL CUTTING
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

CHAINS, DRIVE
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHAINS, FRONT END
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.



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Morse Chain Co., Ithaca, N. Y.

CHAINS Silent (Bushed-Pin Joint)
Link-Belt. Co., 300 W. Pershing Rd., Chicago, Ill.

CHAINS, SILENT (Rocker-Joint)
Morse Chain Co., Ithaca, N. Y.

CHAINS, SLING
Link-Belt. Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHAINS, SPROCKET WHEEL
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CLAMPS, HOSE
Knox Mfg. Co., Philadelphia, Pa.

CLAMPS (Trolley)
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CLAMPS, WIRE ROPE
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, New Jersey.

CLIPS, WIRE ROPE
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, New Jersey.

CLUTCHES
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

COAL CLEANING MACHINERY
American Rheolaveur Corporation, Wilkes-Barre, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

COAL COMPANIES
General Coal Company, Land Title Bldg., Philadelphia, Pa.
Lehigh Coal & Navigation Co., Philadelphia, Pa.
Thorne, Neale & Co., Philadelphia, Pa.

COAL CRUSHERS
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

COAL CRUSHERS & ROLLS
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

COAL CUTTERS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

COAL HANDLING MACHINERY
Conveyor Sales Co., Inc., 299 Broadway, New York City.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

COAL LOADERS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

COAL MINING MACHINERY
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

COAL MINING PLANTS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

COAL SEPARATORS (Pneumatic)
Roberts & Schaefer Co., Chicago, Ill.

COMPRESSORS, AIR
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., 11 Broadway, New York City.

COMPRESSORS, MINE CAR
Ingersoll-Rand Co., 11 Broadway, New York City.

CONCENTRATORS (Table)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

CONCRETE REINFORCEMENT
American Steel & Wire Co., Chicago, Ill., and New York.

CONDENSERS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., 11 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CONTROLLERS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CONVERTORS, COPPER
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CONVEYORS
Conveyor Sales Co., Inc., 299 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

CONVEYOR BEARINGS
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, BELT
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, CHAIN FLIGHT
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, COAL
Conveyor Sales Co., Inc., 299 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS AND ELEVATORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Conveyor Sales Co., Inc., 299 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, PAN OR APRON
Conveyor Sales Co., Inc., 299 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, SCREW
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

COOLERS, Man
Robinson Ventilating Co., Zelienople, Pa.

COOLERS, ROTARY
Vulcan Iron Works, Wilkes-Barre, Pa.

COPPER WIRE & STRAND (Bare)
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

CORE DRILLS, Carbon (Diamonds) for
R. S. Patrick, Sellwood Building, Duluth, Minn.

CORE DRILLING
H. R. Ameling Prospecting Co., Rolla, Mo.
Hoffman Bros. Punxsutawney, Pa.

COUPLINGS, FLEXIBLE
Fawcus Machine Co., Pittsburgh, Pa.

COUPLINGS, ROCK DRILL
Knox Mfg. Co., Philadelphia, Pa.

CROSSINGS AND CROSSOVERS
Central Frog & Switch Co., Cincinnati, Ohio.

CROSSOVERS
Sweet's Steel Co., Williamsport, Pa.

CRUSHERS
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

CRUSHERS, COAL
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CRUSHERS, SINGLE & DOUBLE ROLL
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CRUSHING PLANTS, COKE
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

CUP GREASE
Keystone Lubricating Co., Philadelphia, Pa.

CUTTING APPARATUS, Oxy-Acetylene, Oxy-Hydrogen
Oxweld Acetylene Co., 30 E. 42d St., New York City.

DECARBONIZING APPARATUS
Oxweld Avetylene Co., 30 E. 42d St., New York City.

DESIGNERS OF PLANTS
American Rheolaveur Corporation, Wilkes-Barre, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

DIAMOND CORE DRILL CONTRACTING
H. R. Ameling Prospecting Co., Rolla, Mo.
Hoffman Bros., Punxsutawney, Pa.
Sullivan Machinery Co., Chicago, Ill.

DIAMOND DRILLING CARBON
R. S. Patrick, Sellwood Building, Duluth, Minn.

DIAMONDS, BLACK (See Carbon and Bortz)
R. S. Patrick, Sellwood Building, Duluth, Minn.

DIAMONDS, INDUSTRIAL
R. S. Patrick, Sellwood Building, Duluth, Minn.

DIGGERS & PICKS, Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York City.

DITCHING MACHINES
Keystone Churn Drill Co., Beaver Falls, Pa.

DOORS, AUTOMATIC MINE
American Mine Door Co., Canton, Ohio.

DOWNIE DEEP WELL PUMPS
Keystone Churn Drill Co., Beaver Falls, Pa.

DRIFTERS, DRILL
Ingersoll-Rand Co., 11 Broadway, New York City.

DRILLING CONTRACTORS
Pennsylvania Drilling Co., Pittsburgh, Pa.

DRILLING, DIAMONDS FOR
R. S. Patrick, Sellwood Building, Duluth, Minn.

DRILLS, AIR AND STEAM
Howells Mniing Drill Co., Plymouth, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.

DRILLS (Blast Hole)
Ingersoll-Rand Co., 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

DRILL BITS, Carbon (Diamonds) for
R. S. Patrick, Sellwood Building, Duluth, Minn.

DRILL, CARBON (Diamonds) for
R. S. Patrick, Sellwood Building, Duluth, Minn.

DRILL COLUMNS & MOUNTINGS
Ingersoll-Rand Co., 11 Broadway, New York City.

DRILLER'S DIAMONDS
R. S. Patrick, Sellwood Building, Duluth, Minn.

DRILLS, CORE
H. R. Ameling Prospecting Co., Rolla, Mo.
Hoffman Bros., Punxsutawney, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

DRILLS, ELECTRIC
General Electric Co., Schenectady, N. Y.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

DRILLS, HAMMER
Ingersoli-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

DRILLS (Hand Operated Coal)
Ohio Brass Co., Mansfield, Ohio.

DRILLS, MINERAL PROSPECTING
Keystone Churn Drill Co., Beaver Falls, Pa.

DRILLS, PNEUMATIC
Howells Mining Drill Co., Plymouth, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.

DRILLS, PROSPECTING
H. R. Ameling Prospecting Co., Rolla, Mo.
Hoffman Bros., Punxsutawney, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

DRILLS, ROCK
Diamond Machine Co., Monongahela, Pa.
General Electric Co., Schenectady, N. Y.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

DRILL STEEL SHARPENERS
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

DRIVES, SILENT CHAIN
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

DRUMS (Hoisting, Haulage)
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

DRYERS, ROTARY
Vulcan Iron Works, Wilkes-Barre, Pa.

DUMP CARS
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

DUMPS, ROTARY
Roberts & Schaefer Co., Chicago, Ill.

DYNAMITE
Atlas Powder Co., Wilmington, Del.
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

DYNAMOS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRICAL APPARATUS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRICAL CABLES & WIRES
American Steel & Wire Co., Chicago, Ill., and New York.
Roebling's Sons Co., John A., Trenton, N. J.

ELECTRIC HOISTING MACHINERY
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

ELECTRIC LOCOMOTIVES
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRIC LOCOMOTIVE CABLES
John A. Roebling's Sons Co., Trenton, N. J.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRIC MINE SUPPLIES
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRIC WIRES AND CABLES
American Steel & Wire Co., Chicago and New York.

ELECTRICAL SUPPLIES
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ELECTRICAL WIRES & CABLES
John A. Roebling's Sons Co., Trenton, N. J.

ELECTRODES, WELDING
John A. Roebling's Sons Co., Trenton, N. J.

ELEVATORS
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

ELEVATORS, BUCKET
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

ELEVATOR CABLES & ROPES
John A. Roebling's Sons Co., Trenton, N. J.

ELEVATOR MACHINERY
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

ENGINES, GAS AND GASOLINE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll Rand Co., 11 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ENGINES (Hoisting and Hauling)
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ENGINES, OIL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., 11 Broadway, New York City.

ENGINES, Rope Haulage
S. Flory Mfg. Co., Bangor, Pa.

ENGINES, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., 11 Broadway, New York City.

ENGINES, Winding
S. Flory Mfg. Co., Bangor, Pa.

ENGINEERS
H. R. Ameling Prospecting Co., Rolla, Mo.

EXCAVATORS
Keystone Churn Drill Co., Beaver Falls, Pa.

EXPLOSIVES
Atlas Powder Co., Wilmington, Del.
du Pond Powder Co., The E. I., Wilmington, Del.
Hercules Powder Co., 934 King St., Wilmington, Del.

FAN DRIVES
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FANS, Man Cooling
Robinson Ventilating Co., Zelienople, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FANS, Turbine
Robinson Ventilating Co., Zelienople, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FANS, VENTILATING
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Robinson Ventilating Co., Zelienople, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FEEDERS (Crossover, Kickback, Rotary and Dump)
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Mining Safety Device Co., Bowerston, Ohio.
Roberts & Schaefer Co., Chicago, Ill.

FEEDERS (Hand Operated)
Mining Safety Device Co., Bowerston, Ohio.
Roberts & Schaefer Co., Chicago, Ill.

FEEDERS, ORE
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

FEEDERS (Semi-automatic)
Mining Safety Device Co., Bowerston, Ohio.

FENCE POSTS
Sweet's Steel Co., Williamsport, Pa.

FIRE AND WEATHERPROOF WIRE
John A. Roebling's Sons Co., Trenton, N. J.

FLASHLIGHTS AND BATTERIES (Mine Safety)
National Carbon Co., Inc., 30 East 42d Street, New York City.

FLOORING, OPEN STEEL
Hendrick Mfg. Co., Carbondale, Pa.

FLOTATION MACHINES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

FLOTATION OILS
Hercules Powder Co., 934 King St., Wilmington, Del.

FLOW METERS
General Electric Co., Schenectady, N. Y.

FLUX, WELDING
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

FORGINGS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

FROGS
Sweet's Steel Co., Williamsport, Pa.

FROGS AND SWITCHES
Amer. Mine Door Co., Canton, Ohio.
Central Frog & Switch Co., Cincinnati, Ohio.
West Virginia Rail Co., Huntington, W. Va.

FURNACES, Oil (for drill steel)
Ingersoll-Rand Co., 11 Broadway, New York City.

FURNACES, ROASTING
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

GAS (Cutting, Welding)
Prest-O-Lite Co., Inc., 30 E. 42nd St., New York City.

GAS (Nitrogen, Oxygen)
Linde Air Products Co., 30 E. 42nd St., New York City.

GAUGES, WELDING
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

GEARS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS, BEVEL
Fawcus Machine Co., Pittsburgh, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS, HERRINGBONE
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS, Machine Cut
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, Moulded Tooth
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, Silent Chain
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

GEARS, SPUR
Fawcus Machine Co., Pittsburgh, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS, WORM
Fawcus Machine Co., Pittsburgh, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

GEARS, WORM WHEELS
Fawcus Machine Co., Pittsburgh, Pa.

GENERATORS AND GENERATING SETS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

GENERATORS, ACETYLENE
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

GLOVES, ASBESTOS
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

GOGGLES, WELDING
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

GRATING, AREA, SIDE WALK
Hendrick Mfg. Co., Carbondale, Pa.

GREASE
Keystone Lubricating Co., Philadelphia, Pa.

GRINDERS, Portable Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York City.

GUY ROPES, GALVANIZED
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

HAMMERS, Calking, Chipping & Riveting
Ingersoll-Rand Co., 11 Broadway, New York City.

HANGERS (Insulated Trolley)
Ohio Brass Co., Mansfield, Ohio.

HAULAGE ROPE
American Steel & Wire Co., Chi...cago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

HEADLIGHTS, ARC AND INCANDESCENT
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

HEATER CORD
John A. Roebling's Sons Co., Trenton, N. J.

HERRINGBONE GEAR DRIVES
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

HOIST DRIVES
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

HOISTING ROPES
American Steel & Wire Co., Chicago, Ill., and New York.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
John A. Roebling's Sons Co., Trenton, N. J.

HOISTS
American Steel & Wire Co., Chicago and New York.
Ingersoll-Rand Co., 11 Broadway, New York City.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, AIR
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, ELECTRIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Diamond Machine Co., Monongahela, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOISTS, PORTABLE
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, DERRICK
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, GASOLINE
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Room
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Room and Gathering
S. Flory Mfg. Co., Bangor, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

HOISTS, Scraper-Loader
Ingersoll-Rand Co., 11 Broadway, New York City.

HOISTS, Shaft, Electric
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Shaft, Steam
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Shaker Chute
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Slope, Electric
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Slope, Steam
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOLDERS-ON RIVETING
Ingersoll-Rand Co., 11 Broadway, New York City.

HOOKS
John A. Roebling's Sons Co., Trenton, N. J.

HOSE, AIR AND STEAM
Ingersoll-Rand Co., 11 Broadway, New York City.

HOSE CLAMPS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

HOSE COUPLINGS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

HOSE CONNECTIONS, SPECIAL
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

HOSE MENDERS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

HOSE NIPPLES
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

HOSE, WELDING
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

HYDRATORS, LIME
Vulcan Iron Works, Wilkes-Barre, Pa.

INCINERATORS
Vulcan Iron Works, Wilkes-Barre, Pa.

INSULATORS, FEEDER WIRE
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS, SECTION
Amer. Mine Door Co.,Canton, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS (Porcelain)
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS (Third Rail)
Ohio Brass Co., Mansfield, Ohio.

INSULATORS (Trolley)
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATED WIRE AND CABLE
American Steel & Wire Co., Chicago, Ill.
Roeblings Sons, John A., Trenton, N. J.

KEYSTONE DRILLS
Keystone Churn Drill Co., Beaver Falls, Pa.

KEYSTONE EXCAVATORS
Keystone Churn Drill Co., Beaver Falls, Pa.

KILNS (Rotary)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Vulcan Iron Works, Wilkes-Barre, Pa.

KILNS, VERTICAL
Vulcan Iron Works, Wilkes-Barre, Pa.

LAMP CORD
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

LAMPS, ARC AND INCANDESCENT
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LEAD BURNING APPARATUS, Oxy-Acetylene, Oxy-City Gas
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

LIGHT STEEL ANGLES
Sweet's Steel Co., Williamsport, Pa.
Carnegie Steel Co., Pittsburgh, Pa.

LIGHT STEEL RAILS
Carnegie Steel Co., Pittsburgh, Pa.

LIGHT STEEL RAILS (A. S. C. E. Sections)
Sweet's Steel Co., Williamsport, Pa.

LOADERS (Mine Car)
The Coloder Co., Columbus, Ohio.
Conveyor Sales Co., Inc., 299 Broadway, New York City.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

LOADERS, PORTABLE
Conveyor Sales Co., Inc., 299 Broadway, New York City.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

LOADING BOOMS
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

LOADING MACHINES
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Conveyor Sales Co., Inc., 299 Broadway, New York City.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

LOCOMOTIVES, ELECTRIC
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVES, GASOLINE
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVES, RACK RAIL
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LOCOMOTIVES, STEAM
Vulcan Iron Works, Wilkes-Barre, Pa.

LOCOMOTIVES, STORAGE BATTERY
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVE SWITCHING & WRECKING ROPES
John A. Roebling's Sons Co., Trenton, N. J.

LOCOMOTIVES (Third Rail)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LOCOMOTIVES, TROLLEY
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LONGWALL MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LUBRICANTS
Keystone Lubricating Co., Philadelphia, Pa.

LUBRICATORS
Kekstone Lubricating Co., Philadelphia, Pa.

MACHINERY, TRANSMISSION (Power)
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

MANIFOLDS, OXYGEN
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

MAST ARM ROPE, Galvanized
John A. Roebling's Sons Co., Trenton, N. J.

MENDERS, HOSE
Knox Mfg. Co., Philadelphia, Pa.

MILLS, ROD & BALL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

MILLS, STAMP
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

MINE CAR LUBRICATING
Keystone Lubricating Co., Philadelphia, Pa.

MINE-CARS
Enterprise Wheel & Car Corporation, Huntington, W. Va.

MINE DOORS, AUTOMATIC
American Mine Door Co., Canton, Ohio.

MINE LOCOMOTIVE CABLE
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

MINE SIGNALS
American Mine Door Co., Canton, Ohio.

MINING & METALLURGICAL MACHINERY
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MINING EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING MACHINE CABLE
John A. Roebling's Sons Co., Trenton, N. J.

MINING MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING MACHINES (Electric)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING MACHINES (Government Approved)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

MINING MACHINERY
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING SPECIALTIES
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MOUNTED BOTTOM CUTTERS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

MOVING PICTURE CORD
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

NIPPLES, HOSE
Knox Mfg. Co., Philadelphia, Pa.

NITROGEN GAS
Linde Air Products, 30 East 42nd St. New York City.

NOZZLES, MALLEABLE IRON
Knox Mfg. Co., Philadelphia, Pa.

OILERS, ROCK DRILL
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

OIL RIGS, PORTABLE
Keystone Churn Drill Co., Beaver Falls, Pa.

ORE, BUYERS AND SELLERS OF
Irvington Smelting & Refining Works, Irvington, N. J.
Phelps-Dodge Corporation, New York City.

ORE, CARNOTITE & VANADIUM
O. Barlow Willmarth, Georgetown, Colo.

OVERCUTTING MACH'S.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

OXYGEN GAS
Linde Air Products, 30 East 42nd St., New York City.

OXY-ACETYLENE APPARATUS and SUPPLIES
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

PATENT ATTORNEY
John Boyle, Jr., Ouray Bldg., Washington, D. C.

PAVING BREAKERS
Ingersoll-Rand Co., 11 Broadway, New York City.

PERFORATED METAL
Hendrick Mfg. Co., Carbondale, Pa.

PERMISSIBLES, Explosives
Atlas Powder Co., Wilmington, Del.
du Pont Powder Co., The E. I., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.

PICKING TABLES
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

PIPE (Wood)
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

PNEUMATIC HOSE COUPLINGS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

PNEUMATIC TOOL
Ingersoll Rand Co., 11 Broadway, New York City.

POWDER, BLASTING
Atlas Powder Co., Wilmington, Del.
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Hercules Powder Co., 934 King St., Wilmington, Del.

POWER CABLES
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

POWER SHOVELS
Keystone Churn Drill Co., Beaver Falls, Pa.

POWER TRANSMISSION MACHINERY
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PREHEATING APPARATUS
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

PRESERVATIVE EQUIPMENT
American Lumber & Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.
United Wood Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.

PRESERVATIVES, WOOD
American Lumber & Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.
United Wood Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.

PROSPECTIVE DRILLS
H. R. Ameling Prospecting Co., Rolla, Mo.
Hoffman Bros., Punxsutawney, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.

PULLEYS
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

PULVERIZERS, COAL AND COKE
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

PUMPS, Acid Resisting
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, AIR LIFT
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, Boiler Feed
Ingersoll-Rand Co., 11 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PUMPS CENTRIFUGAL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

PUMPS, DEEP WELL
Ingersoll-Rand Co., 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

PUMPS (Electric)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PUMPS, Fire
Ingersoll Rand Co., 11 Broadway, New York City.

PUMPS (Gathering or Dip)
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

PUMPS, Inclined Shaft
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, MINE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

PUMPS, Sinking
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, PNEUMATIC AIR LIFT
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, POWER
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

PUMPS, SAND
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

PUMPS, STEAM
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

PUMPS, VACUUM
Ingersoll-Rand Co., 11 Broadway, New York City.

PUNCHES, Drill Steel
Ingersoll-Rand Co., 11 Broadway, New York City.

QUARRYING MACHINERY
Ingersoll-Rand Co., 11 Broadway, New York City.

QUARRYING SPECIALTIES
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

RADIO ACTIVE ORE
O. Barlow Willmarth, Georgetown, Colo.

RADIUM ORE
O. Barlow Willmarth, Georgetown, Colo.

RAIL BONDS
American Steel & Wire Co., Chicago and New York.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RAILWAY SUPPLIES
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RAMMERS, Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York City.

RECEIVERS, Air
Ingersoll-Rand Co., 11 Broadway, New York City.

REGULATORS, Welding, Compressed Gas
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

REHEATERS, Air
Ingersoll-Rand Co., 11 Broadway, New York City.

REINFORCING BARS
Sweet's Steel Co., Williamsport, Pa.
West Virginia Rail Co., Huntington, W. Va.

RIVER CROSSING SUSPENSION WIRE, Galvanized
John A. Roebling's Sons Co., Trenton, N. J.

RETARDERS
Mining Safety Device Co., Bowerston, Ohio.

ROCK-DISPOSAL EQUIPMENT
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

ROCK DRILL COUPLINGS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

ROCK DRILL OILERS
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

ROCK DRILLS
Diamond Machine Co., Monongahela, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.

ROCK DRILL THROTTLES
Knox Mfg. Co., 811-821 Cherry St., Philadelphia, Pa.

ROCK DUSTING MACHINES
Diamond Machine Co., Monongahela, Pa.

RODS, WELDING
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

ROLLER BEARINGS
Enterprise Wheel & Car Corporation, Huntington, W. Va.

ROLLS (Crushing)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

ROPE
American Steel & Wire Co., Chicago and New York.

ROPE GREASE
Keystone Lubricating Co., Philadelphia, Pa.

ROPE, TRANSMISSION
American Steel & Wire Co., Chicago and New York.
Roebling Sons, John A., Trenton, N. J.

ROPE, WIRE
American Steel & Wire Co., Chicago and New York.
Roebling Sons, John A., Trenton, N. J.

ROTARY DUMPS
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

ROTARY ROASTERS
Vulcan Iron Works, Wilkes-Barre, Pa.

RUNNING ROPE, Galvanized
American Steel & Wire Co., Chicago and New York.
John A. Roebling's Sons Co., Trenton, N. J.

SAFETY APPLIANCES, MINE
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

SAND DRYERS
Roberts & Schaefer Co., Chicago, Ill.

SASH CORD
John A. Roebling's Sons Co., Trenton, N. J.

SCRAPER LOADERS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

SCREENS, HORIZONTAL
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

SCREENS, PERFORATED METAL
Hendrick Mfg. Co., Carbondale, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

SCREENS, REVOLVING
Hendrick Mfg. Co., Carbondale, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

SCREENS, SHAKER
Hendrick Mfg. Co., Carbondale, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

SCREENS AND PERFORATED SHEETING
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Hendrick Mfg. Co., Carbondale, Pa.

SCREENS & WASHERIES
American Rheolaveur Corporation, Wilkesbarre, Pa.

SEIZING STRAND, GALVANIZED
John A. Roebling's Sons Co., Trenton, N. J.

SHARPENERS, DRILL
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

SHEAVES
John A. Roebling's Sons Co., Trenton, N. J.

SHEAVE WHEELS
Vulcan Iron Works, Wilkes-Barre, Pa.

SHORT WALL ANCHORS
Amer. Mine Door Co., Canton, Ohio.

SHORTWALL MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

SHOVEL—ELECTRO-HYDRAULIC
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

SIGNAL WIRES & CABLES
American Steel & Wire Co., Chicago, Ill., and New York
John A. Roebling's Sons Co., Trenton, N. J.

SIGNS (Mine)
Stonehouse Signs, Inc., 842 Larimer St., Denver, Colo.

SINKERS, ROCK DRILL
Ingersoll-Rand Co., 11 Broadway, New York City.

SKIPS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Hendrick Mfg. Co., Carbondale, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

SKIP LOADING EQUIPMENT
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Chicago, Ill.

SLABBING MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

SMELTERS
Irvington Smelting & Refining Works, Irvington, N. J.

SOCKETS, Open and Closed
John A. Roebling's Sons Co., Trenton, N. J.

SPECIAL MACHINERY
Fawcus Machine Co., Pittsburgh, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.

SPEED REDUCERS, DOUBLE
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

SPEED REDUCERS, SINGLE
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt. Co., 300 W. Pershing Rd., Chicago, Ill.

SPIKES
Sweet's Steel Co., Williamsport, Pa.

SPLICE BARS (Plain and Angle)
Carnegie Steel Co., Pittsburgh, Pa.
Sweet's Steel Co., Williamsport, Pa.

SPLICE, CABLE
American Mine Door Co., Canton, Ohio.
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G. H. Shapter, Commercial Engr., Industrial Dept., General Electric Co., Erie, Pa.

Mining and Loading Equipment

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Frank E. Cash, United States Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
Walter M. Dake, Joy Machine Co., Franklin, Pa.
J. L. Goss, Sales Mgr., Bertrand P. Tracy Co., Fulton, Page & Hopkins Sts., Pittsburgh, Pa.
T. W. Gray, Asst. Supt. of Elec. Equipment, Pittsburgh Coal Co., Library, Pa.
A. C. Green, Goodman Mfg. Co., Chicago, Ill.
G. W. Hay, Genl. Mgr., Consolidation Coal Co., Watson Bldg., Fairmont, W. Va.
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N. D. Levin, Jeffrey Mfg. Co., Columbus, Ohio.
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Norton A. Newdick, The Coloder Co., Columbus, Ohio.
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John S. Beltz, Mining Engineering Dept., Jeffrey Mfg. Co., Columbus, Ohio.
Frank E. Cash, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
T. W. Dawson, Chf. Engr., H. C. Frick Coke Co., Scottdale, Pa.
Thos. G. Fear, Engr. of Transportation, Consolidation Coal Co., Fairmont, W. Va.
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Glen A. Knox, Supt., Gunn-Quealy Co., Gunn, Wyo.
E. F. Miller, Genl. Supt., Bertha-Consumers Co., Rachel, W. Va.
C. W. Nelson, District Sales Manager, Mine Safety Appliances Co., 4505 W. 8th St., Cincinnati, Ohio.
Edw. B. Raiguel, Chf. Engr., Coal Service Corpn., First Natl. Bank Bldg., Huntington, W. Va.
D. A. Stout, Chf. Engr. of Mines, Fuel Dept., Colorado Fuel & Iron Co., Pueblo, Colo.
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J. Charlton Truax, Sales Engr., Bertrand P. Tracy Co., Fulton, Page & Hopkins Sts., Pittsburgh, Pa.
B. A. Walter, Pres., Conveyor Sales Co., 299 Broadway, New York City.
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G. B. Southward (*Chairman*), Mining Engineer, Elkins, W. Va.
A. R. Anderson, Jeffrey Mfg. Co., Columbus, Ohio.
D. J. Carroll, Cons. Engr., 224 South Michigan Ave., Chicago, Ill.
Frank E. Cash, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
Clarence R. Claghorn, Cons. Mng. Engr., 715 Continental Bldg., Baltimore, Md.
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H. F. McCullough, Mechanization Engr., Consolidation Coal Co., Fairmont, W. Va.
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Cecil W. Smith, Asst. Gen. Mgr., O'Gara Coal Co., 1120 McCormick Bldg., Chicago, Ill.
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E. K. Bowers, Asst. Treas., Morgan-Gardner Elec. Co., Harvey, Ill.
Walter Calverley, Pres., W. R. Calverley, Inc., Clarion, Pa.
Frank E. Cash, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
J. M. Clark, Vice-Pres., Clark & Krebs, Inc., Charleston, W. Va.
Wm. E. Hamilton, Mgr., Hamilton Engineering Co., Columbus, Ohio.
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E. F. Austin, Dravo-Doyle Co., Pittsburgh, Pa.
Herbert Axford, Sales Engr., Ingersoll-Rand Co., 610 Spruce St., Scranton, Pa.
J. H. Edwards, Associate Editor, Coal Age, 2962 Winters Rd., Huntington, W. Va.
F. J. Emeny, Vice Pres., The Deming Co., Salem, Ohio.
J. E. Holveck, Dist. Mgr., Aldrich Pump Co., 1209 Empire Bldg., Pittsburgh, Pa.
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Chas. H. Matthews, Genl. Engr., in Chg. Mining Section, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
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Parker Cott (*Chairman*), Salesman, Coal Mine Equipment Co., 2218 Farmers Bank Bldg., Pittsburgh, Pa.
Herbert Axford, Sales Engr., Ingersoll-Rand Co., 610 Spruce St., Scranton, Pa.
Henry E. Cole, Vice Pres., Harris Pump & Supply Co., 320 Second Ave., Pittsburgh, Pa.
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W. L. Robison, Vice Pres., Youghiogheny & Ohio Coal Co., 1230 Hanna Bldg., Cleveland, Ohio.
R. F. Roth, Emmons Coal Mining Co., Altoona, Pa.
Cecil W. Smith, Asst. Genl. Mgr., O'Gara Coal Co., 1120 McCormick Bldg., Chicago, Ill.
M. Spillman, Works Engr., Worthington Pump & Machinery Corpn., Harrison, N. J.
L. D. Tracy, Supt., U. S. Bureau of Mines, 312 Ceramics Bldg., Urbana, Ill.

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John Brunschwyler (*Chairman*), Div. Supt., Boomer Coal & Coke Co., Boomer, W. Va.
Oscar Cartlidge, Cons. Engr., 1593 Lee St., Charleston, W. Va.
L. P. Crecelius, Engr., Cleveland & Western Coal Co., 1517 Union Trust Bldg., Cleveland, Ohio.
E. D. Knight, 2207 Washington St., Charleston, W. Va.
R. Y. Wert, Supt., Durham Coal & Iron Co., Soddy, Tenn.

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J. A. Malady, Master Mech. & Elec. Engr., Hillman Coal & Coke Co., Pittsburgh, Pa.
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Chas. A. Straw, Cons. Mech. Engr., Hudson Coal Co., 434 Wyoming Ave., Scranton, Pa.
G. V. Woody, Mgr., Allis-Chalmers Mfg. Co., Wilkes-Barre, Pa.

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J. A. Malady (*Chairman*), Master Mech. and Elec. Engr., Hillman Coal and Coke Co., First National Bank Bldg., Pittsburgh, Pa.
A. P. Cameron, Vice Pres., Westmoreland Coal Co., Irwin, Pa.
J. H. Doughty, Mechanical Engineer, Lehigh and Wilkes-Barre Coal Co., Wilkes-Barre, Pa.
T. W. Gray, Pittsburgh Coal Co., Library, Pa.
C. L. Harrod, Elec. Engr., Indiana Coal Operators Power Assn., 1509 Merchants Bank Bldg., Indianapolis, Ind.
W. H. Hinks, Engr., Imperial Coal Corpn., Johnstown, Pa.
W. E. Housman, Asst. Mech. Engr., H. C. Frick Coke Co., Scottdale, Pa.
Wm. F. Jacobus, Chemist, Susquehanna Collieries Co., Wilkes-Barre, Pa.
G. G. Kanable, Engineering Dept., Rochester and Pittsburgh Coal and Iron Co., Indiana, Pa.
R. L. Kingsland, Elec. Engr., Consolidation Coal Co., Fairmont, W. Va.
Martin J. Lide, Cons. Engr., Woodward Bldg., Birmingham, Ala.
T. F. McCarthy, Asst. Genl. Supt., Clearfield Bituminous Coal Corpn., Indiana, Pa.
J. D. Martin, Genl. Supt. of Coal Mines, Virginia Iron, Coal and Coke Co., Payne Bldg., Roanoke, Va.
Frank G. Morris, Genl. Supt. of Mines, Republic Iron and Steel Co., Sayreton, Ala.
R. C. Newman, Chief Engineer, Wheeling and Lake Erie Coal Mining Co., 1001 Euclid Place, Huntington, W. Va.
J. M. Provost, Chief Engineer, Pittsburgh Terminal Coal Corpn., Wabash Bldg., Pittsburgh, Pa.
L. D. Rover, Power and Construction Dept., Ford Motor Co., Detroit, Mich.
W. A. Selvig, Associate Chemist, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
W. E. Valentine, Genl. Supt. Cascade Coal and Coke Co., Sykesville, Pa.
M. E. Walthall, Elec. and Mech. Engr., Pennsylvania Coal Co., P. O. Box 553, Scranton, Pa.
P. A. Witherspoon, Chief Engineer, Carnegie Coal Co., Oliver Bldg., Pittsburgh, Pa.

Mine Ventilation

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J. C. Gaskill (*Chairman*), Asst. Cons. Engr., Consolidation Coal Co., Fairmont, W. Va.
C. H. Beidenmiller, Mgr., Glogora Coal Co., 705 First Natl. Bank Bldg., Huntington, W. Va.
J. H. Doughty, Mech. Engr., Lehigh & Wilkes-Barre Coal Co., 16 So. River St., Wilkes-Barre, Pa.
Robert Wallace, Supt., Pocahontas Fuel Co., Inc., Pocahontas, Va.
Jos. J. Walsh, Secretary of Mines, Pennsylvania Dept. of Mines, Harrisburgh, Pa.

OFFICERS AND COMMITTEES, 1927—(Continued)

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R. Dawson Hall (*Chairman*), Engineering Editor, Coal Age, 10th Ave. at 36th St., New York City.
Howard N. Eavenson, Pres., Howard N. Eavenson & Associates, 1302 Union Trust Bldg., Pittsburgh, Pa.
R. H. Moore, Gen. Mgr., C. A. Hughes & Co., Portage, Pa.
E. N. Zern, Editor, Mining Catalog, Keystone Cons. Publishing Co., 29 Lincoln Ave., Crafton, Pittsburgh, Pa.

SUB-COMMITTEE NO. 4—MINE ATMOSPHERE

Thomas Chester (*Chairman*), Cons. Engr., 1318 Cordova Road, Pittsburgh, Pa.
Martin J. Lide, Cons. Engr., Woodward Bldg., Birmingham, Ala.
R. M. Perry, Gen. Supt., Moffat Coal Co., 504 Gas & Elec. Bldg., Denver, Colo.

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H. H. Elkins, Supt. of Mines, Valley Camp Coal Co., St. Clairsville, Ohio.
Geo. Watkins Evans, Coal Mng. Engr., L. C. Smith Bldg., Seattle, Wash.
W. G. Henning, Secretary and Treasurer, A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
M. A. Kendall, Chf. Engr., Stephens-Adamson Mfg. Co., Aurora, Ill.
Rudolf Kudlich, Asst. to Chf. Mech. Engr., U. S. Bureau of Mines, Washington, D. C.
John J. Moore, Dey & Maddock, 82d and Dennison Sts., Cleveland, Ohio.
F. G. Morris, Genl. Supt. of Coal Mines, Republic Iron & Steel Co., Sayreton, Ala.
G. H. Morse, Genl. Supt., Republic Iron & Steel Co., Oliver Bldg., Pittsburgh, Pa.
H. F. Nash, Vice Pres. & Genl. Mgr. of Sales, Oakdale Coal Co., Gas and Electric Bldg., Denver, Colo.
Warren R. Roberts, Pres., Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.
H. D. Smith, Asst. to Pres., Majestic Collieries Co., Peery Bldg., Bluefield, W. Va.
C. R. Stahl, Asst. to Genl. Mgr., E. E. White Coal Co., Stotesbury, W. Va.
C. Law Watkins, Vice Pres., Pennsylvania Coal & Coke Corpn., Cresson, Pa.
F. W. Whiteside, Chf. Engr., Victor-American Fuel Co., Ernest & Cranmer Bldg., Denver, Colo.

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A. B. Kiser, *Chairman*

W. A. Chandler, Elec. Engr., Hudson Coal Co., Scranton, Pa.
Harvey Conrad, Genl. Mgr., American Coal Mng. Co., Bicknell, Ind.
L. C. Ilsley, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.
R. L. Kingsland, Genl. Supt., Power and Mechanical Dept., Consolidation Coal Co., Fairmont, W. Va.
Carl Lee, Elec. Engr., Peabody Coal Co., 1652 McCormick Bldg., Chicago, Ill.
Wm. Schott, Cons. Engr., Big Creek Coal Co., Chicago, Ill.
Henry M. Warren, Cons. Engr., Glen Alden Coal Co., 300 Jefferson Ave., Scranton, Pa.

Power Equipment

F. L. Stone, *Chairman*

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Graham Bright, Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.
Stephen H. Green, Pacific Coast Coal Co., Seattle, Wash.
O. P. Hood, Chf. Mech. Engr., U. S. Bureau of Mines, Washington, D. C.
J. T. Jennings, Power Engr., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.
R. L. Kingsland, Consolidation Coal Co., Fairmont, W. Va.
M. D. Kirk, Vesta Coal Co., Jones & Laughlin Bldg., Pittsburgh, Pa.
Chas. Legrand, Cons. Engr., Phelps Dodge Corpn., Douglas, Ariz.
Martin J. Lide, Cons. Engr., Woodward Bldg., Birmingham, Ala.
J. A. Malady, Master Mech. & Elec. Engr., Hillman Coal & Coke Co., 2307 First National Bank Bldg., Pittsburgh, Pa.
A. J. Nicht, Jr., Engr., Hoisting Equipment, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
W. C. Shunk, Stonega Coal & Coke Co., Big Stone Gap, Va.
Geo. S. Thompson, Chf. Elec. & Master Mech., Colorado Fuel & Iron Co., Pueblo, Colo.
C. D. Woodward, Chf. Elec. Engr., Anaconda Copper Mining Co., 514 Hennessy Bldg., Butte, Mont.

Mine Timbering

R. E. Krape, *Chairman*

SUB-COMMITTEE NO. 1—GENERAL MINE TIMBERING, SIMPLIFICATION ON GRADES AND NAMES

D. F. Holtman (*Chairman*), Asst. Director, National Committee on Wood Utilization, Dept. of Commerce, Washington, D. C.
R. L. Adams, Chf. Engr., Old Ben Coal Corpn., Christopher, Ill.
R. W. Austin, Austin & Wood, North 3rd St., Clearfield, Pa.
J. R. Crowe, Jr., Pres., Crowe Coal Co., Dwight Bldg., Kansas City, Mo.
R. L. Dyer, Engr., Alabama Fuel & Iron Co., Pioneer Bldg., Birmingham, Ala.
G. A. Knox, Supt., Gunn-Quealy Coal Co., Gunn, Wyo.
Ernest M. Merrill, Pres., Merrill-Ferguson Engineering Co., 506 Kanawha Bank & Trust Bldg., Charleston, W. Va.
Davis Read, Chf. Engr., West Kentucky Coal Co., Sturgis, Ky.
George S. Rice, Chf. Mng. Engr., U. S. Bureau of Mines, Washington, D. C.
J. R. Sharp, care of C. F. Kurtz Co., Rock Island, Ill.
Geo. T. Stevens, Chf. Engr., Clinchfield Coal Corpn., Dante, Va.
Frank A. Young, Chf. Engr., St. Louis, Rocky Mountain & Pacific Co., Raton, N. Mex.

SUB-COMMITTEE NO. 2—PRESERVATION OF MINE TIMBERS

Geo. M. Hunt (*Chairman*), In Charge of Wood Preservation Section, Forest Products Laboratory, Madison, Wis.
R. L. Adams, Chf. Engr., Old Ben Coal Corpn., Christopher, Ill.
W. L. Affelder, Asst. to Pres., Hillman Coal and Coke Co., 2306 First Natl. Bank Bldg., Pittsburgh, Pa.
R. W. Austin, Austin & Wood, North 3rd St., Clearfield, Pa.
M. E. Haworth, Chf. Engr., Hillman Coal & Coke Co., First Natl. Bank Bldg., Pittsburgh, Pa.
M. H. Sellers, Timber Agent, Chicago, Wilmington & Franklin Coal Co., Carbondale, Ill.
D. A. Stout, Chf. Engr. of Mines, Fuel Dept., Colorado Fuel & Iron Co., Pueblo, Colo.

SUB-COMMITTEE NO. 3—USE OF CONCRETE IN MINE TIMBERING

Newell G. Alford (*Chairman*), Vice Pres., Howard N. Eavenson & Associates, 1302 Union Trust Bldg., Pittsburgh, Pa.
R. L. Adams, Chf. Engr., Old Ben Coal Corpn., Christopher, Ill.
Jas. R. Barber, Asst. Engr., St. Louis, Rocky Mountain & Pacific Co., Raton, N. Mex.
D. W. Blaylock, Chf. Engr., Madison Coal Corpn., Glen Carbon, Ill.
Walter Buss, Chf. Engr., Knox Consolidated Coal Co., Vincennes, Ind.
B. C. Collier, Pres., Cement-Gun Co., Inc., Allentown, Pa.
W. E. Guller, Chf. Engr., Donk Bros. Coal & Coke Co., Edwardsville, Ill.
Frank Haas, Cons. Engineer, Consolidation Coal Co., Fairmont, W. Va.
Daniel Harrington, U. S. Bureau of Mines, Washington, D. C.
C. T. Hayden, Chf. Engr., Cosgrove-Meehan Coal Corpn., Marion, Ill.
Fred J. Hogan, Mining Engineer, Spangler, Pa.
L. W. Householder, Chf. Engr., Rochester & Pittsburgh Coal & Iron Co., Indiana, Pa.
W. R. Peck, Chf. Engr., Black Diamond Collieries Co., Coal Creek, Tenn.
J. C. Quade, Chf. Engr., Saline County Coal Corpn., Harrisburg, Ill.
C. E. Swann, Chf. Engr., Union Pacific Coal Co., Rock Springs, Wyo.
S. Tescher, Gen. Supt., National Fuel Co., Colorado Bldg., Denver, Colo.
F. W. Whiteside, Chf. Engr., Victor-American Fuel Co., Denver, Colo.
H. S. Wright, Engineer, Structural Bureau, Portland Cement Assn., 33 West Grand Ave., Chicago, Ill.

SUB-COMMITTEE NO. 4—USE OF STRUCTURAL STEEL FOR MINE TIMBERING

J. D. Snyder (*Chairman*), Div. Engr., Consolidation Coal Co., Frostburg, Md.
L. B. Abbott, Chief Engineer, Consolidation Coal Co., Jenkins, Ky.
R. L. Adams, Chf. Engr., Old Ben Coal Corp., Christopher, Ill.
D. W. Blaylock, Mng. Engr., Madison Coal Corpn., Glen Carbon, Ill.
J. M. Clark, Jr., Asst. Engr., E. E. White Coal Co., Mt. Hope, W. Va.
R. V. Clay, Wheeling & Lake Erie Coal Mining Co, Cleveland, Ohio.
N. M. Hench, Carnegie Steel Co., Carnegie Building, Pittsburgh, Pa.
A. W. Hesse, Chf. Coal Mng. Engr., Youngstown Sheet & Tube Co., Nemacolin, Pa.
Robert A. Marble, Carnegie Steel Co., Carnegie Bldg., Pittsburgh, Pa.
Geo. A. Richardson, Mgr., Technical Publicity Dept., Bethlehem Steel Co., Bethlehem, Pa.
J. A. Saxe, Chief Engineer, Bethlehem Mines Corporation, Heilwood, Pa.
Frank A. Young, Chief Engineer, St. Louis, Rocky Mountain & Pacific Co., Raton, N. M.

SUB-COMMITTEE NO. 5—SALVAGE OF MINE TIMBER

George T. Stevens (*Chairman*), Chf. Engr., Clinchfield Coal Corpn., Dante, Va.
R. L. Adams, Chf. Engr., Old Ben Coal Corp., Christopher, Ill.
Frank S. Follansbee, Chief Mining Engineer, Woodward Iron Co., Woodward, Ala.
H. F. McCullough, Engineer in charge of Mechanization of Mines, Consolidation Coal Co., Fairmont, W. Va.

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A. C. Silvius (*Chairman*), Forester, Philadelphia & Reading Coal and Iron Co., Pottsville, Pa.
C. R. Anderson, Professor of Extension Forestry, The Pennsylvania State College, State College, Pa.
M. H. Doolittle, Supt. Carbondale Coal Co., Carbondale, Ohio.
John W. Keller, Chief, State Forest Extension, Harrisburg, Pa.
Edmund Secrest, State Forester, Wooster, Ohio.
J. M. Sloan, Secretary-Treasurer, Anthracite Forest Protective Assn., 431 West Broad St., Hazelton, Pa.
Ralph A. Smith, Secretary-Treasurer, Pennsylvania Forest Products Manufacturers Assn., Tyrone, Pa.
R. D. Tonkin, Forester, Clearfield Bituminous Coal Corpn., Indiana, Pa.
W. D. Tyler, Land Agent, Clinchfield Coal Corporation, Dante, Va.

METAL MINING BRANCH

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Dr. Frank H. Probert, Dean, College of Mining, University of California, Berkeley, Calif.
Philip D. Wilson, American Metal Co., Ltd., 61 Broadway, New York City.

Mine Drainage

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H. T. Abrams, Dept., Mgr. of Air Lift Pumps and "Calyx" Drills, Ingersoll-Rand Co., 11 Broadway, New York City.
G. L. Kollberg, Mgr., Pumping Engine Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
O. D. McClure, Chief Mech. Engr., Cleveland-Cliffs Iron Co., Ishpeming, Mich.
Charles Mendelsohn, Master Mechanic, Old Dominion Company, Globe, Ariz.
M. G. Meyers, Elec. Engr., Copper Range Company, Painesdale, Mich.
W. N. Tanner, Chief Engr., Anaconda Copper Mining Co., 514 Hennessy Bldg., Butte, Mont.
C. D. Woodward, Chief Elec. Engr., Anaconda Copper Mining Co., 514 Hennessy Bldg., Butte, Mont.

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Roy H. Marks, Efficiency Engr., United Verde Extension Mng. Co., Jerome, Ariz.
R. T. Murrill, Efficiency Engr., St. Joseph Lead Co., Rivermines, Mo.
R. A. Scott, Sales Mgr., Denver Rock Drill Mfg. Co., 39th and Williams Sts., Denver, Colo.
W. C. Scott, Supt., Morenci Branch, Phelps Dodge Corpn., Metcalf, Ariz.
George A. Shaw, Mine Supt., Talache Mines, Inc., Talache, Idaho.
H. T. Walsh, Vice Pres., Sullivan Machinery Co., Peoples Gas Bldg., Chicago, Ill.

OFFICERS AND COMMITTEES, 1927—(Continued)

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C. S. Elayer, Cloudcroft, N. Mex.
E. F. Hastings, Salesman, Ingersoll-Rand Co. of Texas, Dominion Hotel, Globe, Ariz.
Chas. S. Hurter, Tech. Representative, E. I. du Pont de Nemours & Co., Inc., 5104 Du Pont Bldg., Wilmington, Del.
Charles B. Officer, Chf. Engr., Sullivan Machinery Co., 122 So. Mich. Ave., Chicago, Ill.
Henry S. Potter, Managing Director, Henry S. Potter, Ltd., 26 Cullinan Bldg., Johannesburg, South Africa.
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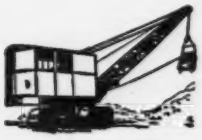

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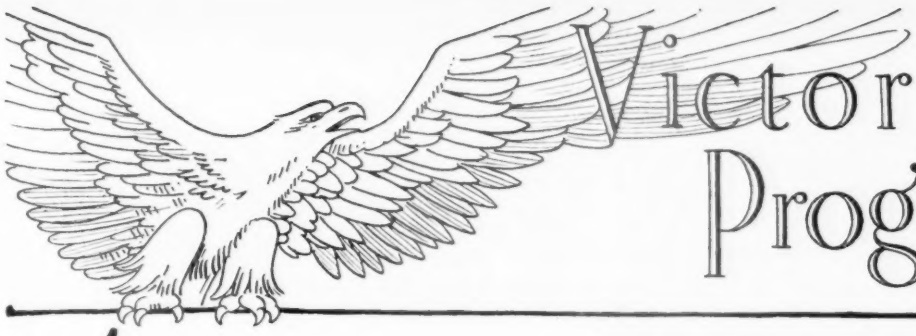

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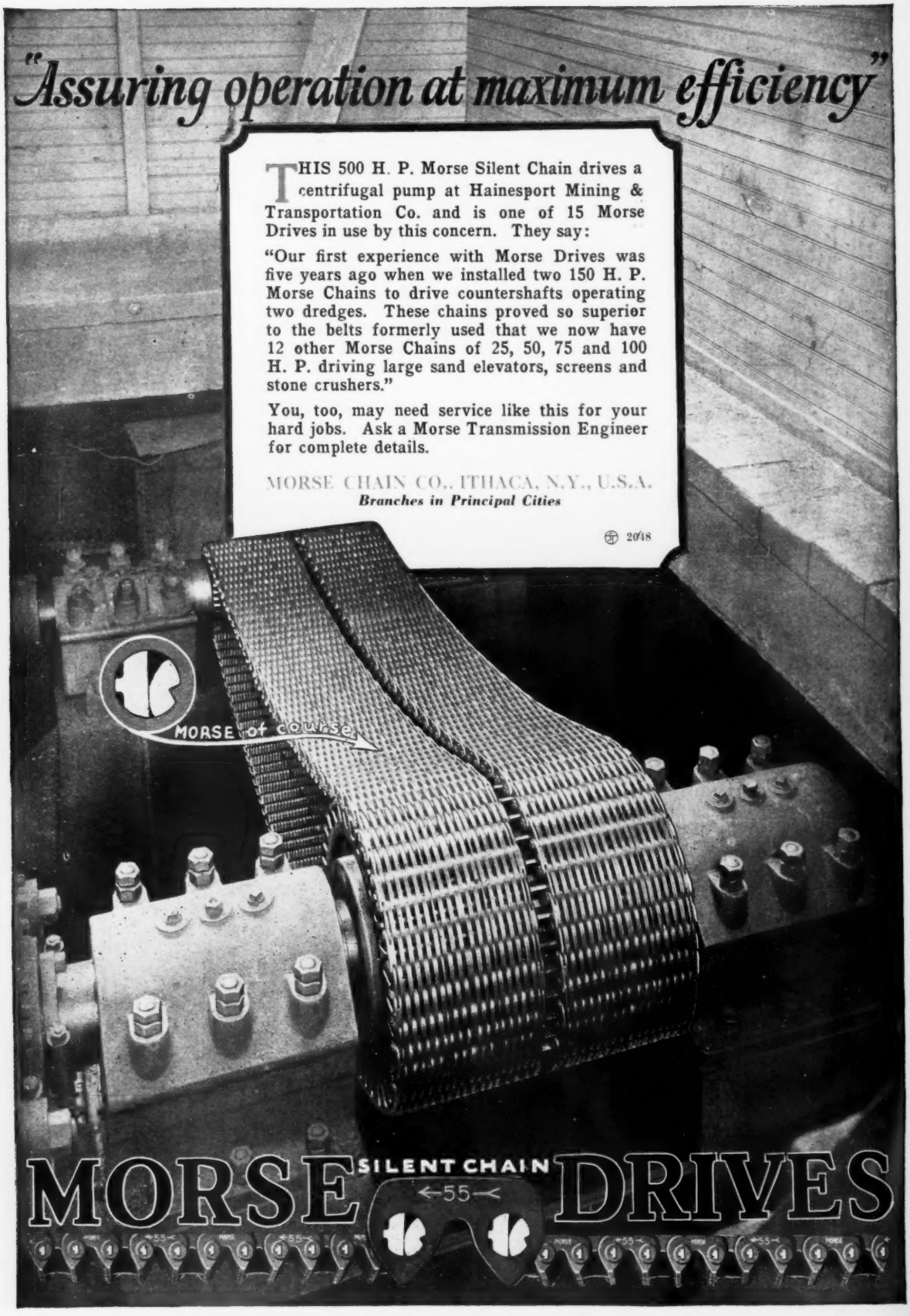

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